Report 2263

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DEPARTMENT OF THE NAVY

DAVID TAYLOR MODEL BASIN
WASHINGTON, D.C.

HYDROMECHANICS

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AERODYNAMICS

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ACOUSTICS AND VIBRATION

MATHEMATICAL MODEL AND COMPUTER PROGRAM FOR TRANSIENT SHOCK ANALYSIS

by

Anthony C. Melodia

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APPLIED MATHEMATICS LABORATORY
RESEARCH AND DEVELOPMENT REPORT

February 1967

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NOTATION

C	Linear damping factor in $C\dot{X}$ in Equation [1]
F_c	Fourier cosine transform value at ω
F_s	Fourier sine transform value at ω
f	Frequency in cycles per second
h	An increment of time
M	Mass
p	Damped natural frequency of linear system
S_n	First forward difference at n
S_n^2	Second forward difference at n
t	Time in seconds
X	Relative displacement (Y-Z) or response displacement
ωX	Pseudo-response velocity
$\omega^2 X$	Pseudo-response acceleration
Y	Absolute displacement of the linear oscillator from its equilibrium position
Z	Displacement of foundation from its equilibrium position
α	Ratio of damping to critical linear damping or damping coefficient
ω	Undamped natural frequency of linear system in radians per second

ABSTRACT

This paper describes a computer program and a mathematical model (developed by G.J. O'Hara of the Naval Research Laboratory) for computing shock and residual shock spectra of linear elastic structures responding to transient forces and foundation motions. A wide range of output options, from tabulated results to a four-coordinate log-log grid, is possible. Included in the mathematical analysis of the shock spectra is a refinement in determining maximum responses, suggested by O'Hara, resulting in a more accurate shock spectrum. The program is written in FORTRAN IV for the IBM 7090 and includes plotting subroutines for the General Dynamics S-C 4020 printer-plotter. The program is also coded without the S-C 4020 subroutines.

ADMINISTRATIVE INFORMATION

The Naval Ship Systems Command (formerly Bureau of Ships) authorized and sponsored this work by Bureau of Ships letter 10460 Serial 732-7 of 5 Feb 1965.

INTRODUCTION

The Naval Ship Systems Command requested the Applied Mathematics Laboratory of the David Taylor Model Basin to develop a series of programs widely applicable in scope for static and dynamic structural analysis. The code presented is a computerization of O'Hara's[1] techniques for shock analysis. The program generates various forms of shock and residual shock spectra for the response of a structure to a transient force or foundation motion when the mathematical model used for the structure is a single-degree-of-freedom linear oscillator. The spectra are used to find the displacement of a structure caused by an arbitrarily prescribed transient motion to its base, such as response of buried structures to an underground blast or response of structures within a vehicle during ballistic impact. In addition, if the input shock function to the program is an acceleration, the residual shock spectrum that is generated is also the Fourier spectrum of the system.

The program is written in FORTRAN IV and is executed on an IBM 7090 using the IBSYS, Version 13, Monitor System in conjunction with a Stromberg-Carlson 4020 printer-plotter. In the appendix, coding is furnished without reference to the plotter, thus making the program more adaptable to other FORTRAN IV compilers.

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[1] References are listed on page 117.

MATHEMATICAL ANALYSIS

The mathematical model for shock analysis here is the simple linear oscillator. The general differential equation for the motion in Figure 1 is

$$M\ddot{Y} + C\dot{X} + KX = F(t) \tag{1}$$

where X is the relative displacement Y-Z, $C\dot{X}$ is the damping term, and KX is the restoring force, based on Hooke's law. Now using standard notation, where C is less than the critical

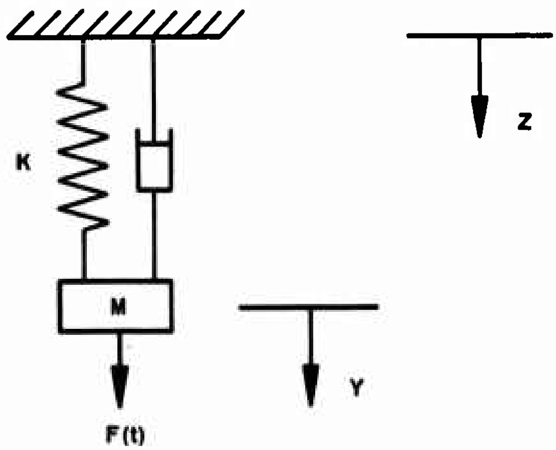


Figure 1 – Linear Oscillator

damping factor, we let

$$\omega^2 = \frac{K}{M}, \quad \alpha = \frac{C}{2M\omega}, \quad \text{and } p = \omega\sqrt{1-\alpha^2}$$

Substituting this into Equation [1], we obtain the following equation

$$\ddot{Y} + 2\alpha\omega\dot{Y} + \omega^2 Y = 2\alpha\omega\dot{Z} + \omega^2 Z + \frac{F(t)}{M} \tag{2}$$

There are two types of motion that are of interest that result from, either no applied force, i.e., $F(t) = 0$ and foundation motion, or no foundation motion, i.e., $Z = 0$ and an applied force. The remainder of this section will mainly describe the first case, where $F(t) = 0$. The latter case, where $Z = 0$, will be dealt with only at the end. The word shock will be used interchangeably with the term input function, namely, $\dot{Z}$, $\ddot{Z}$, or $F(t)$. When $F(t) = 0$, Equation [2] becomes

$$\ddot{Y} + 2\alpha\,\omega\dot{Y} + \omega^2 Y = 2\alpha\,\omega\dot{Z} + \omega^2 Z,$$

or since $Y - Z = X$,

$$\ddot{X} + 2\alpha\,\omega\dot{X} + \omega^2 X = -\ddot{Z} \qquad [3]$$

Using Laplace transforms, we find the solution to Equation [3] to be

$$X(t) = X(0)\,e^{-\alpha\omega t}\left(\cos pt + \frac{\alpha}{\sqrt{1-\alpha^2}}\sin pt\right) + \dot{X}(0)\,\frac{e^{-\alpha\omega t}\sin pt}{p}$$

$$-\frac{1}{p}\int_0^t \ddot{Z}(T)\,e^{-\alpha\omega[t-T]}\sin p(t-T)\,dT \qquad [4]$$

whereas the derivative of Equation [4] is

$$\dot{X}(t) = e^{-\alpha\omega t}X(0)\left[-\alpha\omega\left(\cos pt + \frac{\alpha}{\sqrt{1-\alpha^2}}\sin pt\right) - p\sin pt\right.$$

$$\left. + \frac{p\,\alpha\cos pt}{\sqrt{1-\alpha^2}}\right] + \frac{\dot{X}(0)\,e^{-\alpha\omega t}}{p}(-\alpha\,\omega\sin pt + p\cos pt)$$

$$+\frac{1}{p}\int_0^t \ddot{Z}(T)\,e^{-\alpha\omega[t-T]}\left[\alpha\omega\sin p(t-T) - p\cos p(t-T)\right]dT$$

$$[5]$$

Equation [4] gives the relative response displacement of the mass to the shock $\ddot{Z}(t)$ in terms of given initial displacements and velocities. The solution of the differential equation is not useful yet, for the integral must be evaluated. Nów, if the solution were known at $t = t_1$, the values of relative displacement (X) and relative velocity ($\dot{X}$) could be considered initial values at t_1 for the solution at $t_1 + \Delta t$, using Equations [4] and [5] again. A convenient procedure followed in the numerical solution of the differential equation consists of subdividing the time record into equal increments, each of duration $\Delta t = h$ seconds, so the method of evaluating $X(t)$ at each point will require the same equations. Of course, the values of X and $\dot{X}$ at the beginning of the time record must be given to use this procedure for solving the differential equation, and also the input function $\ddot{Z}$ must be digitized into equal increments. A parabolic approximation for $\ddot{Z}(t)$ between 0 and h is substituted in

Equations [4] and [5], then the integrals are evaluated. In addition, the approximation for $\ddot{Z}(t)$ at any point in the time record will go through its preceding point as well as its successive point. If the time is subdivided into enough intervals, h, no sudden peaks of $\ddot{Z}$ should be missed by the approximating parabola for $\ddot{Z}$.

A useful change in notation follows: $X(ih) = X_i$, $\ddot{Z}(ih) = \ddot{Z}_i$, where $\ddot{Z}_i$ is the $(i + 1)$ *th* point in the time record, $i = 0, 1, 2, 3, \ldots, k$, and $k + 1$ is the number of points in the time record.

The parabola passing through $\ddot{Z}_{n-1}$, $\ddot{Z}_n$, $\ddot{Z}_{n+1}$ yields the equation

$$\ddot{Z}(t) = \frac{(\ddot{Z}_{n+1} - 2\ddot{Z}_n + \ddot{Z}_{n-1})}{2h^2} t^2 + \frac{(\ddot{Z}_{n+1} - \ddot{Z}_{n-1})}{2h} t + \ddot{Z}_n \qquad [6]$$

for $(n - 1)h \leq t \leq (n + 1)h$. A few notational changes will simplify Equation [6]: let

$$S_n = \ddot{Z}_{n+1} - \ddot{Z}_n \text{ and } S^2_{n-1} = S_n - S_{n-1} = \ddot{Z}_{n+1} - 2\ddot{Z}_n + \ddot{Z}_{n-1}$$

so Equation [6] becomes

$$\ddot{Z}(t) = \ddot{Z}_n + \frac{S_n t}{h} + \frac{S^2_{n-1}}{2}\left(\frac{t^2}{h^2} - \frac{t}{h}\right) \qquad [7]$$

Now, using Equation [7] in the integral in place of $\ddot{Z}(t)$ in Equation [4], integrating by parts from 0 to h, and finally substituting h for t in the other terms of Equation [4] lead to the final equation for the response at each point in the time record:

$$\omega X_{n+1} = \omega X_n e^{-\alpha\omega h}\left(\cos ph + \frac{\alpha}{\sqrt{1-\alpha^2}} \sin ph\right)$$

$$+ \dot{X}_n \frac{e^{-\alpha\omega h} \sin ph}{\sqrt{1-\alpha^2}} - \frac{\ddot{Z}_n}{\omega}\left[1 - e^{-\alpha\omega h}\left(\cos ph + \frac{\alpha}{\sqrt{1-\alpha^2}} \sin ph\right)\right]$$

$$- \frac{S_n}{\omega}\left[1 - \frac{2\alpha}{\omega h}(1 - e^{-\alpha\omega h} \cos ph) - \frac{(1-2\alpha^2)\, e^{-\alpha\omega h} \sin ph}{ph}\right]$$

$$- \frac{S_{n-1}^2}{2\omega} \left\{ - \frac{4\alpha}{\omega h} - \left[2 \, \frac{(1 - 4\alpha^2)}{\omega^2 h^2} - \frac{2\alpha}{\omega h} \right] (1 - e^{-\alpha\omega h} \cos ph) \right.$$

$$\left. + \left[\frac{1 - 2\alpha^2}{\omega h} + 2\alpha \, \frac{(3 - 4\alpha^2)}{\omega^2 h^2} \right] \frac{e^{-\alpha\omega h} \sin ph}{\sqrt{1 - \alpha^2}} \right\} \qquad [8]$$

and using the same method in developing Equation [8] transforms Equation [5] into

$$\dot{X}_{n+1} = - \omega X_n \, \frac{e^{-\alpha\omega h} \sin ph}{\sqrt{1 - \alpha^2}} + \dot{X}_n \, e^{-\alpha\omega h} \left(\cos ph - \frac{\alpha}{\sqrt{1 - \alpha^2}} \sin ph \right)$$

$$- \frac{\ddot{Z}_n}{\omega} \, \frac{e^{-\alpha\omega h} \sin ph}{\sqrt{1 - \alpha^2}} - \frac{S_n}{\omega} \left[\frac{1}{\omega h} - \frac{e^{-\alpha\omega h}}{\omega h} \left(\cos ph + \frac{\alpha}{\sqrt{1 - \alpha^2}} \sin ph \right) \right]$$

$$- \frac{S_{n-1}^2}{\omega} \left\{ \frac{2}{\omega h} - \left(\frac{1}{\omega h} + \frac{4\alpha}{\omega^2 h^2} \right) (1 - e^{-\alpha\omega h} \cos ph) \right.$$

$$\left. - \left[\frac{2 \, (1 - 2\alpha^2)}{\omega^2 h^2} - \frac{\alpha}{\omega h} \right] \frac{e^{-\alpha\omega h} \sin ph}{\sqrt{1 - \alpha^2}} \right\} \qquad [9]$$

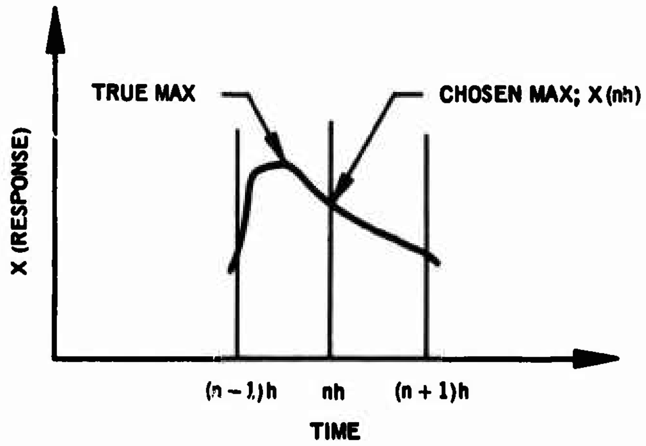
The response X is scaled by ω in Equation [8], because ωX is a meaningful quantity, as will be explained later. Consider a time record of $\ddot{Z}$ versus time; the initial values must be given before Equations [8] and [9] can be used, i.e., $X(t_0)$ and $\dot{X}(t_0)$ must be known. Also, S_0 for $t = t_0 + h$ is $Z(t_0 + h) - Z(t_0)$, and S_{n-1}^2 where $n = 1$, becomes $\ddot{Z}(2h + t_0) - 2\ddot{Z}(h + t_0) + \ddot{Z}(t_0)$.

Of more interest to the engineer is not the response (X) at each point in the time record for a particular frequency, but the maximum or minimum response for each frequency over a given range of frequencies. Essentially, for the given range of frequencies one obtains the maximum response as a function of frequency. The maximum and minimum response ($X\omega$) for each frequency is selected from the values of $X\omega$ for the complete time record. The refinement of the maximum and minimum (a more accurate estimate) is achieved by first noting that the product of $\dot{X}_{max}$, the derivative of the chosen X_{max}, and $\dot{X}_{max-h}$, the derivative of X_{max-h}, is positive if X_{max} reaches its true maximum between X_{max} and X_{max+h} and is negative if the true maximum occurs between X_{max} and X_{max-h}; this is illustrated by the two possibilities that follow

Here, let $X_{max} = X(nh)$, $X_{max+h} = X((n+1)h)$, and $X_{max-h} = X((n-1)h)$

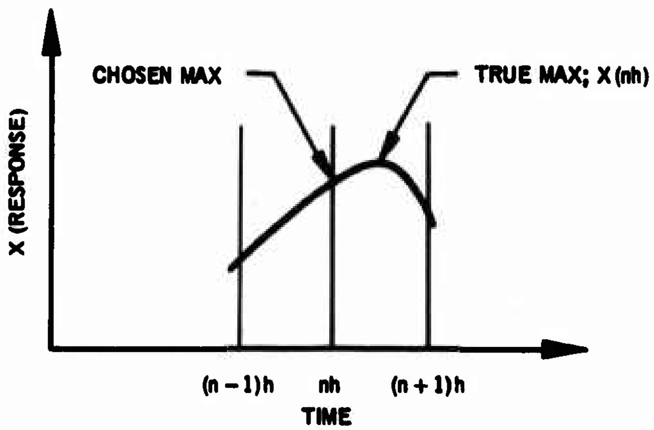
Possibility 1

$\dot{X}((n-1)h) \cdot \dot{X}(nh)$ is negative, so true maximum occurs between X_{max-h} and X_{max}



Possibility 2

$\dot{X}((n-1)h) \cdot \dot{X}(nh)$ is positive, so true maximum occurs between X_{max} and X_{max+h}



Equation [8] is used after it is determined whether the true maximum or minimum is within the range of X_{max-h}, X_{max} or X_{max}, X_{max+h}. $X\omega$ is then evaluated at intervals of $0.2h$, and the largest $X\omega$ in the subinterval is taken as the more accurate (refined) maximum. The method for computing the refined minimum value of $X\omega$ is the same. The calculation for $X\omega$ at a given frequency is stopped at a time which corresponds to the start of residual time (when the shock or impulse ceases), which is usually determined by the experimenter from examining the plot of the input function $\ddot{Z}(t)$.

Some definitions of variables appearing in the mathematical analysis are in order at this point.

X = response displacement

$X\omega$ = pseudo-response velocity

$X\omega^2$ = pseudo-response acceleration

$\dot{X}$ = true response velocity

$\sqrt{(X\omega)^2 + \dot{X}^2}$ = residual response (in velocity units) at the end of the time record, i.e., at the beginning of residual time. The residual response is computed only when there is no damping.

The shock spectrum is usually the plot of maximum $|X\omega|$ versus f, where f is $2\pi\omega$, and the residual shock spectrum is a plot of $\sqrt{(X\omega)^2 + \dot{X}^2}$ versus f.

When $\omega = 0$, equations for $X\omega$ and $\dot{X}$ as already presented become meaningless, even though X at $\omega = 0$ has physical meaning. New equations are derived from [8] and [9] by using L'Hospital's rule. In Equations [8] and [9] ω is set equal to zero, and when an indeterminant form is encountered, L'Hospital's rule is used; therefore, yielding

$$X_{n+1} = X_n + \dot{X}_n h - \frac{\ddot{Z}_n h^2}{2} - \frac{S_n h^2}{6} + \frac{h^2}{24} S^2_{n-1} \qquad [10]$$

$$\dot{X}_{n+1} = -\ddot{Z}_n h - S_n \frac{h}{2} + \frac{S^2_{n-1} h}{12} \qquad [11]$$

It is observed that damping does not play any role in the foregoing equations.

An added feature of the residual shock spectrum solution is that, if the input shock function is an acceleration ($\ddot{Z}$), then the Fourier spectrum is identical to the residual shock spectrum. The Fourier spectrum magnitude at ω is defined as $(F_c^2 + F_s^2)^{1/2}$, where it is found that

$$F_c = -X\omega \sin \omega t - \dot{X} \cos \omega t$$

and

$$F_s = X\,\omega \cos \omega t - \dot{X} \sin \omega t$$

By substitution, $(F_c^2 + F_s^2)^{1/2}$ becomes $[(X\,\omega)^2 + \dot{X}^2]^{1/2}$, which is the residual shock spectrum magnitude for ω. The Fourier spectrum is not necessarily equivalent to the residual shock spectrum when the input shock spectrum is $\dot{Z}$. A thorough discussion of Fourier spectra can be found in Reference 1. The author is presently finishing a program dealing with Fourier spectra such as computing the Fourier spectrum magnitude, the phase angle, the Fourier cosine transform, and the Fourier sine transform, so a detailed description of Fourier spectra will be contained in a subsequent report from the Applied Mathematics Laboratory at the David Taylor Model Basin.

Until now the input shock function was assumed to be $\ddot{Z}$ (foundation acceleration), so the necessary equations for an input function which is the foundation velocity ($\dot{Z}$) will now be considered.

$$S_n = \dot{Z}_{n+1} - \dot{Z}_n$$

$$S_{n-1}^2 = S_n - S_{n-1} = \dot{Z}_{n+1} - 2\dot{Z}_n + \dot{Z}_{n-1}$$

$$\dot{Z}(t) = \dot{Z}_n + S_n \frac{t}{h} + \frac{S_{n-1}^2}{2}\left(\frac{t^2}{h^2} - \frac{t}{h}\right) \qquad [12]$$

where $\ddot{Z}$ is replaced by $\dot{Z}$.

$$X_{n+1}\,\omega = X_n\,\omega\, e^{-\alpha\omega h}\left(\cos ph + \frac{\alpha}{\sqrt{1-\alpha^2}} \sin ph\right) + \frac{\dot{X}_n\, e^{-\alpha\omega h} \sin ph}{\sqrt{1-\alpha^2}}$$

$$- \frac{S_n}{\omega h}\left[1 - e^{-\alpha\omega h}\left(\cos ph + \frac{\alpha}{\sqrt{1-\alpha^2}} \sin ph\right)\right]$$

$$- \frac{S_{n-1}^2}{\omega h}\left\{\frac{1}{2} - \frac{2\alpha}{\omega h} + e^{-\alpha\omega h}\left[\left(\frac{1}{2} + \frac{2\alpha}{\omega h}\right)\cos ph\right.\right.$$

$$\left.\left. - \left(\frac{1-2\alpha^2}{\omega h} - \frac{\alpha}{2}\right)\frac{\sin ph}{\sqrt{1-\alpha^2}}\right]\right\} \qquad [13]$$

$$\dot{X}_{n+1} = -X_n \, \omega e^{-\alpha\omega h} \frac{\sin ph}{\sqrt{1-\alpha^2}} + \dot{X}_n e^{-\alpha\omega h}\left(\cos ph - \frac{\alpha}{\sqrt{1-\alpha^2}} \sin ph\right)$$

$$- \frac{S_n}{\omega h} \; \frac{e^{-\alpha\omega h} \sin ph}{\sqrt{1-\alpha^2}} - \frac{S^2_{n-1}}{\omega h}\left\{\frac{1}{\omega h} - e^{-\alpha\omega h}\left[\frac{\cos ph}{\omega h}\right.\right.$$

$$\left.\left. + \left(\frac{\alpha}{\omega h} + \frac{1}{2}\right) \frac{\sin ph}{\sqrt{1-\alpha^2}}\right]\right\} \qquad [14]$$

Equation [13] is obtained from Equation [4] by first integrating by parts, secondly, substituting [12] for $\dot{Z}(t)$ in the new integral, integrating again by parts, and finally substituting h for t in the other terms of Equation [4]. Equation [14] is obtained in a similar manner, using Equation [5] in place of Equation [4]. When ω equals 0,

$$X_{n+1} = X_n + \dot{X}_n h - \frac{S_n h}{2} + \frac{S_n^2 h}{12}$$

and

$$\dot{X}_{n+1} = \dot{X}_n - S_n$$

The rest of the calculations using $\dot{Z}$ are the same as those using $\ddot{Z}$, except that for the $\dot{Z}$ input, the residual shock spectrum is *not* necessarily identical to the Fourier spectrum.

Finally, to solve a problem where there is no foundation motion but an applied force $F(t)$, we must solve the differential equation.

$$\ddot{X} + 2\alpha \; \omega \dot{X} + \omega^2 X = \frac{F(t)}{M} \qquad [15]$$

Equations [15] and [3] are the same except for their right-hand members, so if the input function is an applied force, viz., $F(t)$, then, since $\ddot{Z}(t) = -\dfrac{F(t)}{M}$, all of the F_i's are scaled by $-\dfrac{1}{M}$ and the input function is treated as if it were $\ddot{Z}(t)$. The output would correctly be the response to $F(t)$.

OUTLINE OF THE PROGRAM

The Roman numeral headings below correspond to the comment cards in the program listing. Tables 1 and 2 and the flow charts in the following section should aid in understanding the ensuing outline. In addition, Ø is used to denote an alphabetic O in FORTRAN. The Roman numeral above any figure in the flow chart corresponds to a numeral in the following description.

I. Input

Data is read, such as the forcing function ($\dot{Z}$ or $\ddot{Z}$), output options, and other constants.

*IP*3 (four-coordinate grid option) is checked for zero, if not zero, *IP*1 and *IP*2 (other plots) are deleted even if they are requested.

II. Write and Plot Input Data

The time T corresponding to each Z is generated by use of the time interval H.

Each Z and corresponding T are written. From statements 110 to 123, Z versus T is plotted.

III. Compute *S*(*N*) and *S2ND*(*N*) for Each Time T

Each *S* and *S2ND* are computed.

A frequency card is read, i.e., *FREQ*1, *FREQ*2, *DELTAF*, then if *FREQ*1 = *FREQ*2, the blank card was read, indicating the run is finished. If *FREQ*1 ≠ *FREQ*2 the program continues.

The number of frequencies is computed from the card just read, i.e., *NØFREQ* = (*FREQ*2 − *FREQ*1)/*DELTAF*.

IV. Damped or Undamped; if Undamped, Find Number of Residual Points

The large *DØ-loop*, which is indexed for each alpha, is executed.

IALPHA is set equal to one if no damping is present ($\alpha = 0$), or set equal to two if there is damping ($\alpha \neq 0$). If no damping is present, the start of residual time is computed, viz., $T(KH)$.

V. Compute Constants

Many mathematical expressions used repeatedly in the program are computed.

IFREQ is set equal to one if the frequency is zero or is set equal to two if the frequency is not zero.

Finally, there is a major branch in the program, depending on whether (1) $Z = \dot{Z}$ and frequency = 0, (2) $Z = \dot{Z}$ and frequency ≠ 0, (3) $Z = \ddot{Z}$ and frequency = 0, and (4) $Z = \ddot{Z}$ and frequency ≠ 0. Of the four possibilities just mentioned only possibility 2 will be assumed in the rest of the discussion.

VI. Compute *XØMEGA (N)*, *XDØT* For Velocity Input

More constants and mathematical expressions are evaluated. *N XØMEGA*'s and *XDØT*'s are computed in a *DØ-loop* ending at statement 210.

Then there is transfer to preliminary calculations.

VII. Preliminary Calculations for Minimum and Maximum Response

Maximum and minimum *XØMEGA*'s are determined; then control is transfered to statement 225.

Statements 225 to 235 contain the refinement calculations for maximum and minimum $X\ \omega$.

Then from statements 211 to 215 the different output features, which are selected in the input, are executed.

VIII. Either Restart With New Frequency or Restart With New Alpha or Stop

FREQ and *FREQ*2 are compared; if equal, the end of the alpha *DØ-loop* is reached–statement 800–and either the entire calculation is restarted for a new alpha, or the next frequency card is read.

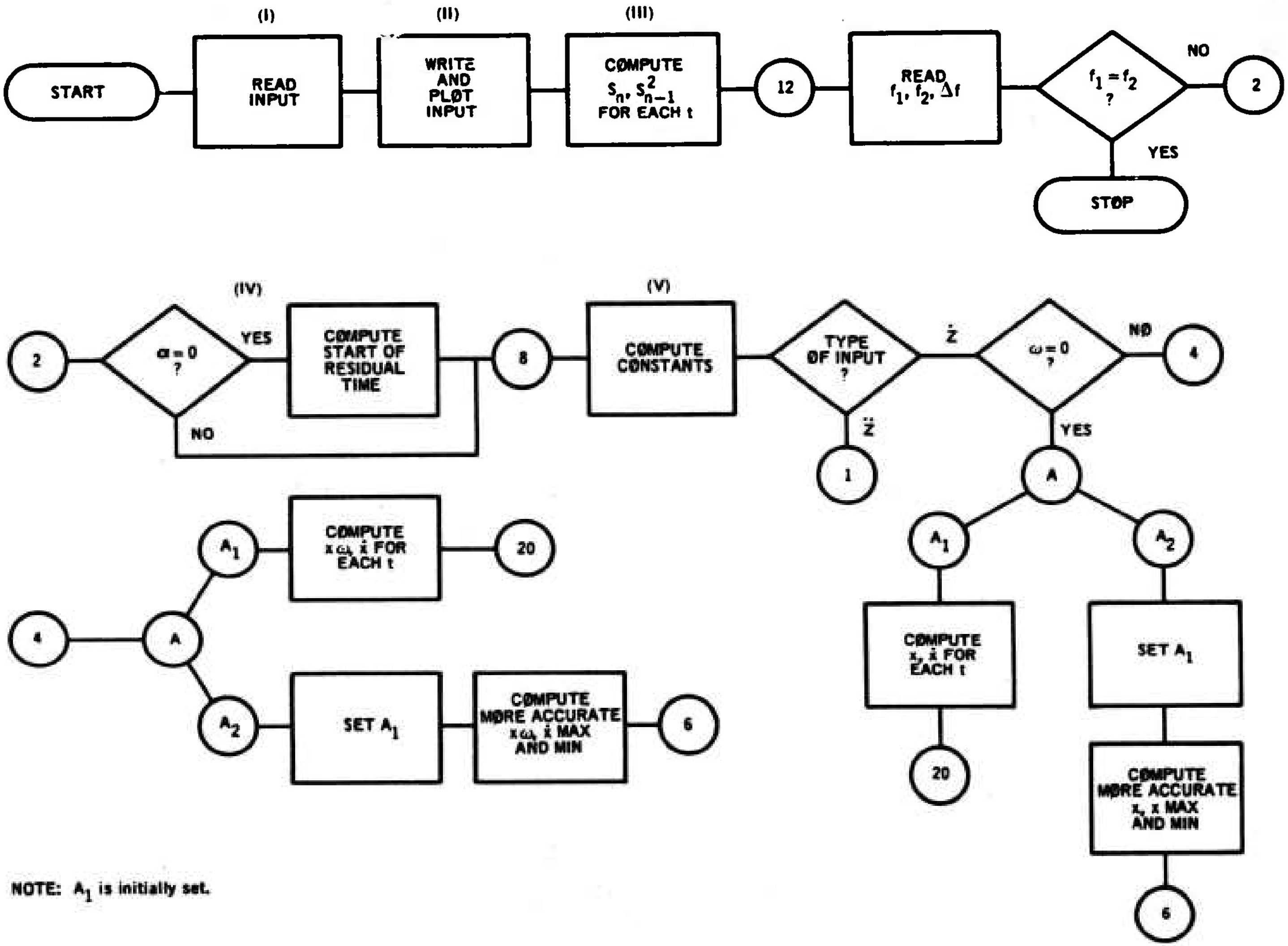
If $FREQ \neq FREQ2$, then *FREQ* is incremented by *DELTAF*, and the calculations for *XØMEGA*, *XDØT*, etc. are repeated.

TABLE 1

Glossary of Important FORTRAN Variables (Excluding Input Variables)

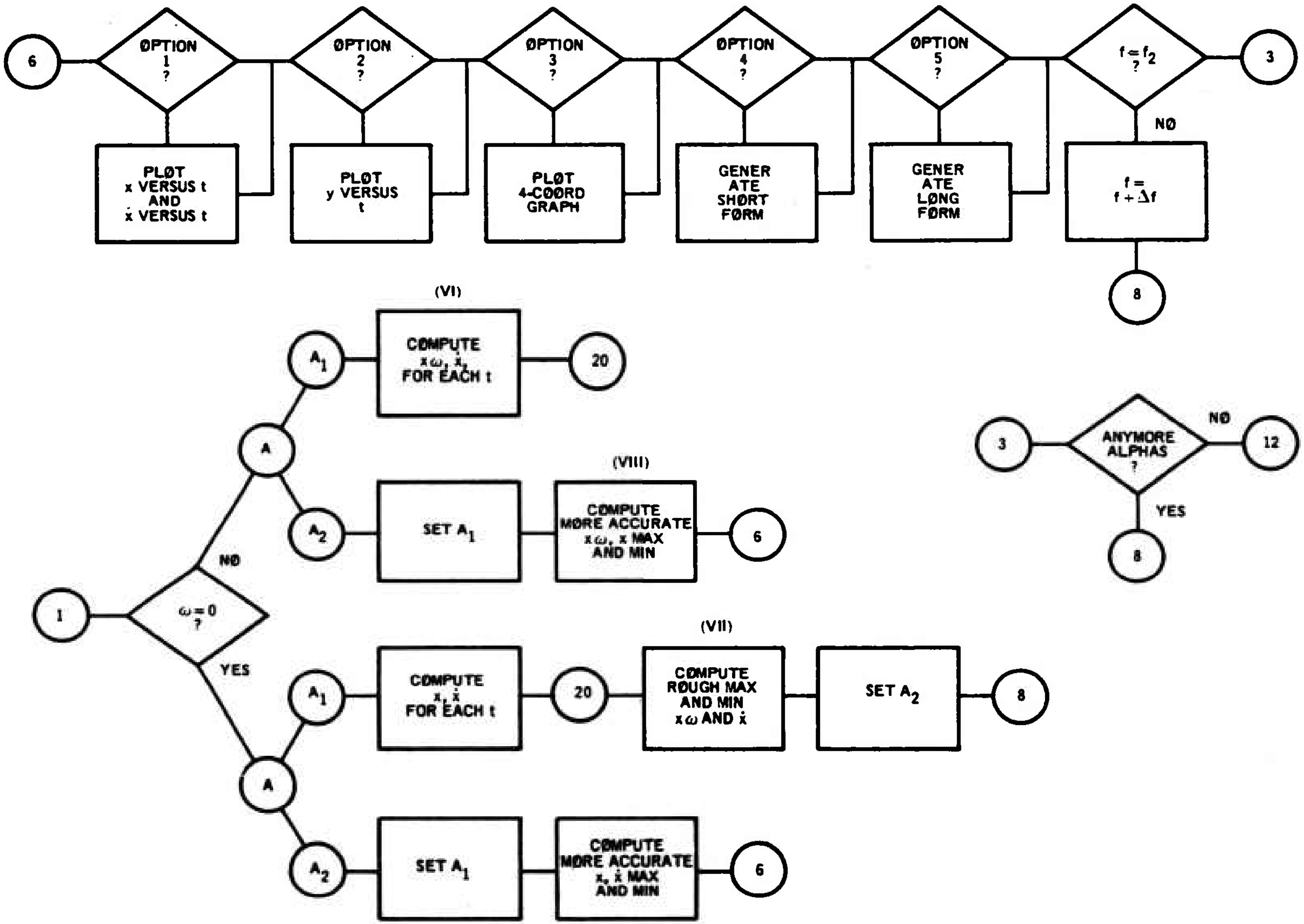
Variable	Math Symbol and/or Explanation
	Dimensioned
S	S_i, first forward difference where $S_i = Z_{i+1} - Z_i$.
S2ND	S_i^2, second forward difference where $S_i^2 = Z_{i+1} - 2Z_i + Z_{i-1}$.
XØMEGA	$X\omega$ (and X when $\omega = 0$) response displacement times natural frequency.
X	X, response displacement, used for plotting in *IP*1, also used for plotting $-\omega^2 X$ in *IP*2.
XDØT	$\dot{X}$, response velocity.
ØSCIL	F, frequency.
VEL	Maximum absolute value of $X\omega$ for each ω.
RESID	$\sqrt{(X\omega)^2 + \dot{X}^2}$, at the start of residual time.
	Undimensioned
*A*1	$10^{LØP}$, which is the value of the first *A*-line drawn on the four-coordinate graph (lower left-hand corner).
*D*1	$10^{LØP}$, which is the value of the first *D*-line drawn on the four-coordinate graph (upper left-hand corner).
IER	Number of points out of range when plotting response (X) versus time in *IP*1.
IERA	Number of points out of range when plotting response velocity ($\dot{X}$) versus time in *IP*1.
IERB	Number of points out of range when plotting $-X\omega^2$ versus time in *IP*2.
IERR	Number of points out of range when plotting the input function *Z*.

FLOW CHART



NOTE: A_1 is initially set.

FLOW CHART (Continued)



INPUT

The input is read into the computer mostly in the form of FORTRAN NAMELISTS; consequently, the format for the data is not very restrictive. The data are usually on punched cards. If the shock function Z is available on an analog tape, a conversion to digitized tape or to cards must be accomplished before the program can be used. Of course, the NAMELISTS can be replaced by regular format statements, which would be mandatory if the program was converted to FORTRAN II.

See Table 2 for the list of input variables with an explanation of each variable. *ZAZA*1 to *ZAZA*4 are NAMELIST names, each containing one or more variables. (See any IBM FORTRAN IV manual for an explanation of NAMELISTS.) The data cards are arranged as follows: *$DATA* card first, then *$ZAZA*1 data, *$ZAZA*2 data, *$ZAZA*3 data, *$ZAZA*4 data, frequency cards, and finally the system cards: *END ØF FILE*, *$IBSYS*, *$RESTØRE*, and *END ØF FILE*.

There is no limit to the number of frequency ranges that can be handled, at one card per range. The last card must be a blank card. The frequency cards are read under format statement 920, viz., 3F20.8, so the decimal point of the first number *FREQ*1 is in column 12, that of the second number *FREQ*2 in column 32, and that of the last number *DELTAF* in column 52. *FREQ*1 must not equal *FREQ*2; therefore, the first number on the frequency card must be less than the second number. The number of frequencies, (*FREQ*2 − *FREQ*1) ÷ *DELTAF*, must not exceed the storage capacity of the variable *ØSCIL* when using *IP*3, which is now dimensioned for 1000 words.

If *IP*1 to *IP*5 are set equal to zero, the only output that will result is a plot of the input function, a tabulation of the input function, and a tabulation of S_i and S_i^2.

If the shock function Z is not on cards, but generated from a formula inserted into the program, then the *READ* (5, *ZAZA*1) statement must be deleted from the program.

The physical units for most of the quantities used in this program are assumed consistent. The units for the input quantities determine the units for the output values except where specified; for example, the input frequencies should be in cycles per second.

TABLE 2

Input Variables

FORTRAN Name	Comment
Z	Shock function which is dimensioned, either acceleration or velocity.
T	Initial time, really *T*(1), and is usually zero.
TZERØ	Starting time of residual shock, i.e., end of transient.
H	Time increment into which record is subdivided.
XO	Response displacement at time *T*, usually zero.
N	Number of points, i.e., number of *Z*'s, must not exceed the dimensioned value for *Z* in the *DIMENSIØN* statement.
XDØTØ	Response velocity at time *T*, usually zero.
ISZ	If $ISZ = 0$, then $Z = \dot{Z}$; if $ISZ \neq 0$, then $Z = \ddot{Z}$.
*IP*1	Output Option 1, if $IP1 = 0$, ignored; if $IP1 \neq 0$, plots of response displacement versus time and response velocity versus time are generated for each frequency and each alpha.
*IP*2	Output Option 2, if $IP2 = 0$, ignored; if $IP2 \neq 0$, a plot of negative pseudo-response acceleration versus time is generated for each frequency and each alpha.
*IP*3	Output Option 3, if $IP3 = 0$, ignored; if $IP3 \neq 0$, a four-coordinate, log-log graph is produced for each range of frequencies submitted, as well as for each alpha, consisting of response displacement versus frequency, pseudo-response velocity versus frequency, pseudo-response acceleration versus frequency, and, if no damping (alpha = 0), residual response velocity versus frequency. If *IP*3 is used, i.e., $IP3 \neq 0$, the program will inhibit *IP*1 and *IP*2.
*IP*4	Output Option 4 is ignored if $IP4 = 0$; if $IP4 \neq 0$, tabulation of results is generated (see output for explanation).
*IP*5	Output Option 5 is ignored, if $IP5 = 0$; if $IP5 \neq 0$, tabulation of results, more extensive than *IP*4, is generated (see output for explanation).
ALPHA	Damping coefficient, which is dimensioned.
NALPHA	Number of damping coefficients submitted and must not be greater than the dimension of *ALPHA* in the *DIMENSIØN* statement.
*FREQ*1	Initial frequency in cycles per second.
*FREQ*2	Last frequency in cycles per second.
DELTAF	Frequency increment in cycles per second.

OUTPUT

The output from the program is composed of a plot and tabulation of the input shock function, a printout of each S_k and S_k^2, and the input options. If the printed S_k and S_k^2 are not desired, the statement immediately following statement 200 in the program should be removed.

See Figures 3 and 8 for an example graph of an input function and Sample Problems 1 and 2 for the tabulation of all points plotted for the input functions. Sample Problems 1 and 2 (Appendixes A and B) also include sample printouts of S_k and S_k^2.

Figures 9, 10, 12, and 13 are examples of *IP*1, which is a plot of X versus time and $\dot{X}$ versus time for each frequency and each alpha (damping coefficient).

*IP*2, illustrated in Figures 11 and 14, is a plot of $-\omega^2 X$ versus time for each frequency and each alpha. The quantity $-\omega^2 X$ is equivalent to the absolute acceleration, $\ddot{Y}$, when $Z = 0$.

*IP*3, illustrated in Figures 4–6 and 15–18, is a four-coordinate, log-log grid which is a plot of velocity (ordinate) versus frequency (abscissa), with acceleration lines having negative slope and velocity lines having positive slope superimposed on an originally two-coordinate grid. The value of the A lines increases logarithmically from left to right, and the line labeled A in the lower left corner of the grid corresponds to the value for A printed in the lower right margin. The value of the D lines decreases downward logarithmically, and the line labeled D in the upper left corner of the grid corresponds to the value for D printed in the lower right margin. The shock spectrum is the starred plot ($X\omega$ versus f), and the residual shock spectrum ($\sqrt{(X\omega)^2 + \dot{X}^2}$ versus f), plotted only when $\alpha = 0$, is the plot of zero points. One complete four-coordinate graph is generated for each frequency range and damping coefficient α. Hence, for any given frequency within the plotted range, one could read from the starred curve the pseudo-acceleration A, the pseudo-velocity, and the displacement D; one could also read from the zero curve, provided there is no damping, the residual shock spectrum magnitude.

*IP*4 (Short Form) is, for each frequency range and damping coefficient, a tabulation of frequency, the maximum value between the pseudo-velocity ($X\omega$) and the residual response ($\sqrt{(X\omega)^2 + \dot{X}^2}$), and, if no damping is present, the residual response.

*IP*5 (Long Form) is, for each frequency range and damping coefficient, a tabulation of frequency, maximum positive pseudo-velocity, minimum negative pseudo-velocity, and, if no damping is present, the residual response. See the sample problems for examples of *IP*4 and *IP*5 (Short and Long Forms).

One method for utilizing the various graphical outputs is first to generate the log-log grid (shock spectrum) from *IP*3, then select from the shock spectrum the important frequencies. Next, these frequencies are used as input in running the program a second time for *IP*1 and/or *IP*2 to produce response versus time plots for each desired frequency.

OPERATING INSTRUCTIONS

The subroutines required are from the IBM 7090 plotting package written by North American Aviation for the Stromberg-Carlson 4020 (charactron plotter-printer). If the S-C 4020 is not available to the user, the alternate deck is used, in which no S-C 4020 subroutines are called, and there are only two output options, *IP*4 and *IP*5 (see Appendix C).

No input tapes, except for unit 5, are required; the program is run under *IBSYS* version 13. Three output tapes are needed for the program, one tape for the S-C 4020, if used; logical tape unit 6; and logical tape unit 8. *IP*4 is written on unit 8, and *IP*5 is written on unit 6.

An approximation of the running time of the program, using the input setup from Sample Problem 1 (see Figure 2), is about 7 minutes, including compiling time. The running time for the program is increased considerably if more than just a few frequencies are used with *IP*1 and *IP*2.

Most of the memory is used (32*K*); see the dimension statement of the program-listing for the array sizes which influence the amount of memory needed.

ACKNOWLEDGMENT

The author wishes to thank George J. O'Hara for his expert guidance and advice on the engineering analysis and the organization of the program.

APPENDIX A

SAMPLE PROBLEM 1

Arrangement of Input Data

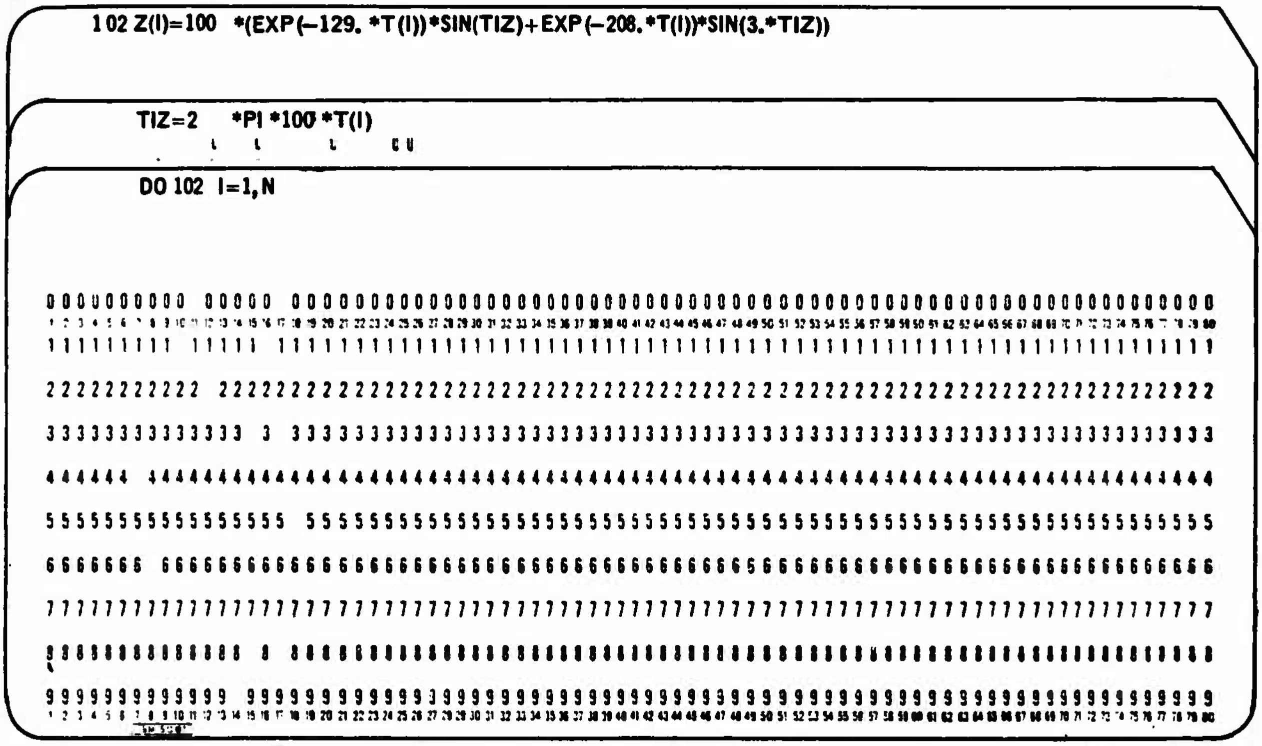
and

All the Various Forms of Output That Can Be

Generated Except $IP1$ and $IP2$

SAMPLE PROBLEM 1

The input shock function is a foundation acceleration, $\ddot{Z} = 100\ [e^{-12\ 9t} \sin 200\ \pi t + e^{-208t} \sin 600\ \pi t]$, which is generated in the program for each desired point. The following cards are inserted at the beginning of the program to generate the $\ddot{Z}$'s.



See Figure 2 for the arrangement of the input data.

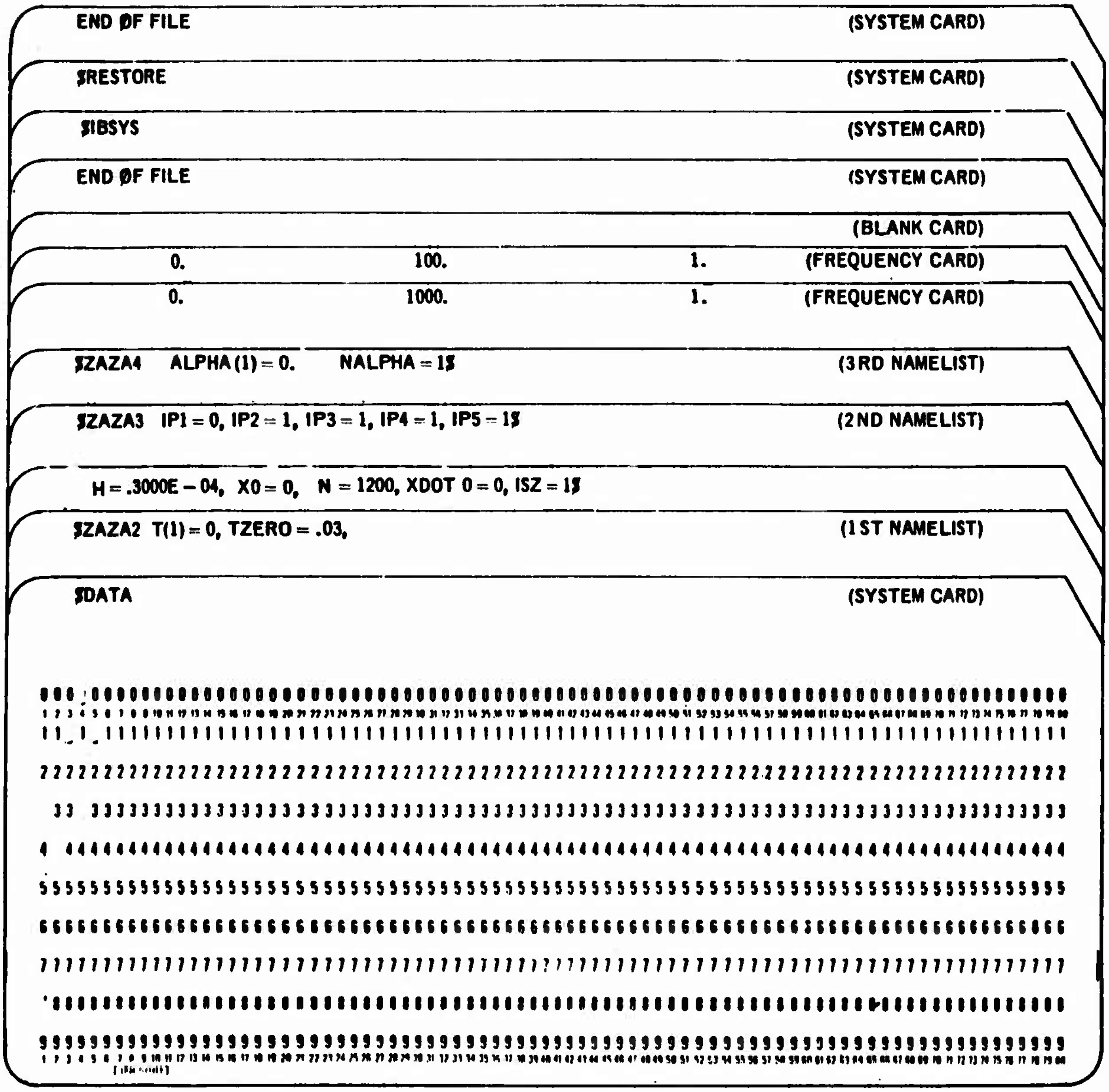


Figure 2 – Arrangement of Input Data for Sample Problem 1

NOTE: NAMELIST $ZAZA1 is omitted because the Z_i's are generated within the program.

PROGRAM LISTING FOR SAMPLE PROBLEM 1


```
        SNERD       -  EFN   SOURCE STATEMENT  -  IFN(S)  -

      DIMENSION Z(2000),T(2000),S(2000),S2ND(2000),XOMEGA(2000),X(2000),
     1XDOT(2000),ALPHA(25),OSCIL(1000) ,VEL(1000),RESID(1000)
      EQUIVALENCE (RESID,X(1)),(VEL,X(1001))
      NAMELIST/ZAZA1/Z/ZAZA2/T,TZERO,                  H,     XO,N,
     1XDOTO,ISZ/ZAZA3/IP1,IP2,IP3,IP4,IP5/ZAZA4/ALPHA,NALPHA
      WRITE(6,900)
      PI=3.1415927
      READ(5,ZAZA2)
      READ(5,ZAZA3)
      READ(5,ZAZA4)
      IF(IP3)50,51,50
   50 IP1=0
      IP2=0
   51 CONTINUE
C
C-----------WRITE AND PLOT INPUT DATA--------------
      DO 100 I=2,N
  100 T(I)=T(I-1)+H
      DO 102 I=1,N
      TIZ=2.*PI*100.*T(I)
  102 Z(I)=100.*(EXP(-129.*T(I))*SIN(TIZ)+EXP(-208.*T(I))*SIN(3.*TIZ))
      IF(ISZ)104,105,104
  104 WRITE(6,901)
      GO TO 106
  105 WRITE(6,902)
  106 CONTINUE
      WRITE(6,903) (Z(I),T(I),I=1,N)
      ZMIN=Z(1)
      ZMAX=Z(1)
      DO 110 I=2,N
      IF(ZMAX-Z(I))108,109,109
  108 ZMAX=Z(I)
      GO TO 110
  109 IF(ZMIN-Z(I))110,110,107
  107 ZMIN=Z(I)
  110 CONTINUE
      CALL CAMRAV(35)
      ZN=N
      DX=H*ZN/10.
      DY=(ZMAX-ZMIN)/10.
      CALL GRIDIV(1,T(1),T(N),ZMIN,ZMAX,DX,DY,1,1,1,1,6,6)
      CALL APLOTV(N,T,Z,1,1,1,42,IERR)
      IF(IERR)115,116,115
  115 WRITE(6,904) IERR
  116 CONTINUE
      NN=N-1
      DO 120 I=1,NN
      CALL LINEV(NXV(T(I)),NYV(Z(I)),NXV(T(I+1)),NYV(Z(I+1)))
  120 CONTINUE
      CALL PRINTV(-15,15HTIME IN SECONDS,452,6)
      IF(ISZ)121,122,121
  121 CALL APRNTV(0,-14,-23,23HFOUNDATION ACCELERATION,4,696)
      GO TO 123
  122 CALL APRNTV(0,-14,-19,19HFOUNDATION VELOCITY,4,664)
  123 CONTINUE
```

```
C
C----------COMPUTE S(N) AND S2ND(N) FOR EACH TIME,T--------
      S(1)=Z(2)-Z(1)
      S2ND(1)=Z(3)-2.*Z(2)+Z(1)
       K=N-1
      DO 200 I=2,K
      S(I)=Z(I+1)-Z(I)
  200 S2ND(I)=Z(I+1)-2.*Z(I)+Z(I-1)
      WRITE(6,917) (I,S(I),S2ND(I),I=1,N)
C
  190 READ(5,920) FREQ1,FREQ2,DELTAF
      IF(ABS(FREQ1-FREQ2)-.1E-20) 801,801,191
  191 CONTINUE
      IF(IP3)192,195,192
  192 TEMP=FREQ2-FREQ1
      IF(AMOD(TEMP,DELTAF)-DELTAF/2.)193,194,194
  193 NOFREQ=TEMP/DELTAF
      GO TO 195
  194 NOFREQ=TEMP/DELTAF+1.0001
  195 CONTINUE
C------DAMPED OR UNDAMPED,IF UNDAMPED FIND NUMBER OF RESIDUAL POINTS---------
      DO 800 IX=1,NALPHA
      NIN=1
      INI=0
      FREQ=FREQ1
      IF(ABS(ALPHA(IX))-.1E-09)201,201,202
  201 IALPHA=1
      GO TO 222
  202 IALPHA=2
  222 GO TO (203,207),IALPHA
  203 TT=TZERO-T(1)
       IF(AMOD(TT,H)-H/2.)205,204,204
  204 KH=TT/H+1.000001
      GO TO 207
  205 KH=TT/H+.000001
  207 CONTINUE
C
C---------COMPUTE CONSTANTS-------
      OMEGA=FREQ*2.*PI
      RADCAL=SQRT(1.-ALPHA(IX)**2)
      OH=OMEGA*H
      P=OMEGA*RADCAL
      EX=EXP(-ALPHA(IX)*OH)
      COSPH=COS(P*H)
      SINPH=SIN(P*H)
      A2OH=2.*ALPHA(IX)/OH
      RECOH=1./OH
       ALPHA2=ALPHA(IX)**2
      X12=1.-2.*ALPHA2
      FACT1=EX*SINPH/RADCAL
      FACT2=EX*COSPH+FACT1*ALPHA(IX)
      IF(ABS(FREQ)-.1E-20)220,220,221
  220 IFREQ=1
      GO TO 223
  221 IFREQ=2
  223 IF(ISZ)300,208,300
```

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          SNERD        -  EFN    SOURCE STATEMENT  -  IFN(S)  -

  208 GO TO (400,209),IFREQ
  209 CONTINUE
C
C------COMPUTEXOMEGA(N),XDOT FOR VELOCITY INPUT------------
      GO TO(224,225),NIN
  224 XOMEGA(1)=OMEGA*XO
      FACT3=RECOH*(1.-FACT2)
      FACT4=RECOH*(.5-2.*ALPHA(IX)*RECOH+EX*((.5+2.*ALPHA(IX)*RECOH)
     1*COSPH-(X12*RECOH-ALPHA(IX)/2.)*SINPH/RADCAL))
      FACT5=EX*COSPH-ALPHA(IX)*FACT1
      FACT6=RECOH*FACT1
      FACT7=(RECOH**2)*(1.-EX*(COSPH+(ALPHA(IX)+OH/2.)*SINPH/RADCAL))
      XDOT(1)=XDOTO
      DO 210 I=2,N
      XOMEGA(I)=XOMEGA(I-1)*FACT2+XDOT(I-1)*FACT1-S(I-1)*FACT3-S2ND(I-1)
     1*FACT4
  210 XDOT(I)=-XOMEGA(I-1)*FACT1+XDOT(I-1)*FACT5-S(I-1)*FACT6-S2ND(I-1)*
     1FACT7
       GO TO 756
  225 CONTINUE
      KRO=KMX+KOOK
      KRA=KMN+KICK
      DO 235 I=2,5
      VA=I-1
      TA=VA*.2*H
      COSPT=COS(P*TA)
      SINPT=SIN(P*TA)
      EXT=EXP(-ALPHA(IX)*OMEGA*TA)
      FACTR1=EXT*(COSPT+ALPHA(IX)*SINPT/RADCAL)
      FACTR2=EXT*SINPT/RADCAL
      FACTR3=(1.-FACTR1)*RECOH
      FACTR4=(TA/H-.5-A2OH+(ALPHA(IX)/2.-X12*RECOH)*FACTR2+(.5+A2OH)
     1*EXT*COSPT)*RECOH
      XMAXO    =XOMEGA(KRO)*FACTR1+XDOT(KRO)*FACTR2-S(KRO)*FACTR3
     1-S2ND(KRO)*FACTR4
      IF(XMAX-XMAXO    )229,230,230
  229 XMAX=XMAXO
  230 XMINO    =XOMEGA(KRA)*FACTR1+XDOT(KRA)*FACTR2-S(KRA)*FACTR3
     1-S2ND(KRA)*FACTR4
      IF(XMIN-XMINO    )235,235,232
  232 XMIN=XMINO
  235 CONTINUE
      NIN=1
  211 IF(IP1)500,212,500
  212 IF(IP2)550,213,550
  213 IF(IP3)600,214,600
  214 IF(IP4)650,215,650
  215 IF(IP5)700,785,700
C
C-----COMPUTE XOMEGA(N), XDOT(N), FOR ACCELRATION INPUT--------
  300 CONTINUE
      GO TO(350,305),IFREQ
  305 CONTINUE
      ECOS1=1.-EX*COSPH
      DFACT3=(1.-FACT2)/OMEGA
      DFACT4=(1.-A2OH*ECOS1-X12*FACT1*RECOH)/OMEGA
```

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         SNERD       -  EFN    SOURCE  STATEMENT  -  IFN(S)  -

      GO TO(308,325),NIN
  308 XOMEGA(1)=OMEGA*X0
      DFACT5=(-4.*ALPHA(IX)-(2.*(1.-4.*ALPHA2)/OH-2.*ALPHA(IX))*ECOS1+
     1(X12+2.*ALPHA(IX)*(3.-4.*ALPHA2)/OH)*FACT1)*RECOH/(2.*OMEGA)
      DFACT6=(1.-ECOS1)-FACT1*ALPHA(IX)
      DFACT7=FACT1/OMEGA
      DFACT8=(1.-FACT2)*RECOH/OMEGA
      DFACT9=(2.-(1.+4.*ALPHA(IX)*RECOH)*ECOS1-(2.*X12*RECOH-ALPHA(IX))
     1*FACT1)*RECOH/(2.*OMEGA)
      XDOT(1)=XDOTO
      DO 310 I=2,N
      XOMEGA(I)=XOMEGA(I-1)*FACT2+XDOT(I-1)*FACT1-Z(I-1)*DFACT3-S(I-1)
     1*DFACT4-S2ND(I-1)*DFACT5
  310 XDOT(I)=-XOMEGA(I-1)*FACT1+XDOT(I-1)*DFACT6-Z(I-1)*DFACT7
     1       -S(I-1)*DFACT8-S2ND(I-1)*DFACT9
       GO TO 756
  325 CONTINUE
      KRO=KMX+KOOK
      KRA=KMN+KICK
      H2=H**2
      DO 335 I=2,5
      VA=I-1
      TA=VA*.2*H
      COSPT=COS(P*TA)
      SINPT=SIN(P*TA)
      EXT=EXP(-ALPHA(IX)*OMEGA*TA)
      FACTR1=EXT*(COSPT+ALPHA(IX)*SINPT/RADCAL)
      FACTR2=EXT*SINPT/RADCAL
      FACTR3=(1.-FACTR1)/OMEGA
      FACTR4=(TA/H-A2OH*(1.-EXT*COSPT)-X12*FACTR2*RECOH)/OMEGA
      FACTR5=(TA**2/H2-TA/H-(2.*(1.-4.*ALPHA2)*RECOH**2-A2OH)*
     1(1.-EXT*COSPT)+(X12*RECOH+2.*ALPHA(IX)*(3.-4.*ALPHA2)*RECOH**2)
     2*FACTR2)/(2.*OMEGA)
      XMAXO=XOMEGA(KRO)*FACTR1+XDOT(KRO)*FACTR2-Z(KRO)*FACTR3
     1-S(KRO)*FACTR4-S2ND(KRO)*FACTR5
      IF(XMAX-XMAXO    )329,330,330
  329 XMAX=XMAXO
  330 XMINO=XOMEGA(KRA)*FACTR1+XDOT(KRA)*FACTR2-Z(KRA)*FACTR3
     1-S(KRA)*FACTR4-S2ND(KRA)*FACTR5
      IF(XMIN-XMINO    )335,335,332
  332 XMIN=XMINO
  335 CONTINUE
      NIN=1
      GO TO 211
C
C------FREQ1=ZERO FOR FOUNDATION ACCELERATION---------
  350 GO TO(352,365),NIN
  352 XOMEGA(1)=X0
      XDOT(1)=XDOTO
      H2=H**2
      DO 360 I=2,N
      XOMEGA(I)=XOMEGA(I-1)+H*XDOT(I-1)-Z(I-1)*H2/2.-S(I-1)*H2/6.+
     1S2ND(I-1)*H2/24.
  360 XDOT(I)=-Z(I-1)*H-S(I-1)*H/2.+S2ND(I-1)*H/12.
      GO TO 756
  365 CONTINUE
```

```
      NIN=1
      GO TO 211
C
C-------COMPUTE X, XDOT FOR OMEGA=ZERO-----VELOCITY INPUT
  400 GO TO(402,425),NIN
  402 XOMEGA(1)=XO
      XDOT(1)=XDOTO
      DO 410 I=2,N
      XOMEGA(I)=XOMEGA(I-1)+XDOT(I-1)*H-S(I-1)*H*.5+S2ND(I-1)*H/12.
  410 XDOT(I)=XDOT(I-1)-S(I-1)
      GO TO 756
  425 CONTINUE
      NIN=1
      GO TO 211
C
C--------PLOT X VS. T AND XDOT VS. T-------------
  500 GO TO(505,510),IFREQ
  505 DO 506 I=1,N
  506 X(I)=XOMEGA(I)
      GO TO 518
  510 DO 515 I=1,N
  515 X(I)=XOMEGA(I)/OMEGA
  518  XMX=X(1)
       XDMX=XDOT(1)
       XMN=X(1)
       XDMN=XDOT(1)
      DO 530 I=2,N
      IF(X(I)-XMX )521,521,520
  520  XMX=X(I)
  521 IF(X(I)-XMN )522,523,523
  522  XMN=X(I)
  523 IF(XDOT(I)-XDMX )525,525,524
  524  XDMX=XDOT(I)
  525 IF(XDOT(I)-XDMN )526,530,530
  526  XDMN=XDOT(I)
  530 CONTINUE
      DY=(XMX -XMN )/ZN
      CALL GRIDIV(1,T(1),T(N),XMN, XMX, DX,DY,4,4,4,4,6,6)
      CALL APLOTV(N,T,X,1,1,1,42,IER)
      IF(IER)531,532,531
  531 WRITE(6,913) IER,FREQ
  532 NN=N-1
      DO 535 I=1,NN
      CALL LINEV(NXV(T(I)),NYV(X(I)),NXV(T(I+1)),NYV(X(I+1)))
  535 CONTINUE
      CALL PRINTV(-15,15HTIME IN SECONDS,452,6)
      CALL PRINTV(-23,23HFREQ=        CYCLES/SEC.,20,3)
      CALL LABLV(FREQ,60,3,6,1,4)
      CALL PRINTV(-8,8HALPHA=  ,20,17)
      CALL LABLV(ALPHA(IX),72,17,6,1,1)
      CALL APRNTV(0,-14,-11,11HX  RESPONSE,4,600)
      DY=(XDMX -XDMN )/ZN
      CALL GRIDIV(1,T(1),T(N),XDMN, XDMX, DX,DY,4,4,4,4,6,6)
      CALL APLOTV (N,T,XDOT, 1,1,1,42,IERA)
      IF(IERA) 538,539,538
  538 WRITE(6,914) IERA,FREQ
```

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          SNERD       -  EFN   SOURCE STATEMENT  -  IFN(S)  -

  539 DO 540 I=1,NN
      CALL LINEV(NXV(T(I)),NYV(XDOT(I)),NXV(T(I+1)),NYV(XDOT(I+1)))
  540 CONTINUE
      CALL PRINTV(-15,15HTIME IN SECONDS,452,6)
      CALL PRINTV(-23,23HFREQ=          CYCLES/SEC.,20,3)
      CALL LABLV(FREQ,60,3,6,1,4)
      CALL PRINTV(-8,8HALPHA=  ,20,17)
      CALL LABLV(ALPHA(IX),72,17,6,1,1)
      CALL APRNTV(0,-14,-22,22HVELOCITY RESPONSE XDOT,4,688)
      GO TO 212
C
C---------PLOT Y(ACCELERATION) VS. TIME----------
  550 CONTINUE
      GO TO(213,551),IFREQ
  551 CONTINUE
  560 DO 562 I=1,N
  562 X(I)=-XOMEGA(I)*OMEGA
       XMX=X(1)
       XMN=X(1)
      DO 566 I=2,N
      IF(XMX -X(I))563,564,564
  563  XMX=X(I)
  564 IF(XMN -X(I))566,566,565
  565  XMN=X(I)
  566 CONTINUE
      DY=(XMX -XMN )/ZN
      CALL GRID1V(1,T(1),T(N),XMN, XMX, DX,DY,4,4,4,4,6,6)
      CALL APLOTV(N,T,X,1,1,1,42,IERB)
      IF(IERB)570,571,570
  570 WRITE(6,919) IERB,FREQ
  571 NN=N-1
      DO 575 I=1,NN
      CALL LINEV(NXV(T(I)),NYV(X(I)),NXV(T(I+1)),NYV(X(I+1)))
  575 CONTINUE
      CALL PRINTV(-15,15HTIME IN SECONDS,452,6)
      CALL PRINTV(-23,23HFREQ=          CYCLES/SEC.,20,3)
      CALL LABLV(FREQ,60,3,6,1,4)
      CALL PRINTV(-8,8HALPHA=  ,20,17)
      CALL LABLV(ALPHA(IX),72,17,6,1,1)
      CALL APRNTV(0,-14,-26,26HABSOLUTE OR Y ACCELERATION,4,720)
      GO TO 214
C
C
C--------------FOUR COORDINATE GRID------
  600 CONTINUE
      INI=1+INI
      OSCIL(INI)=FREQ
      VEL(INI)=AMAX1(ABS(XMAX),ABS(XMIN))
      GO TO (601,602),IALPHA
  601 RESID(INI)=SQRT(XOMEGA(KH)**2+XDOT(KH)**2)
      IF(RESID(INI)-.1E-19)604,604,602
  602 IF(FREQ-.1E-19)604,604,603
  603 IF(VEL(INI)-.1E-19)604,604,605
  604 NOFREQ=NOFREQ-1
      INI=INI-1
  605 IF(ABS(FREQ-FREQ2)-.1E-09)606,606,214
```

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```
        SNERD      -  EFN   SOURCE STATEMENT  -  IFN(S)  -
  606 CONTINUE
      CALL SMXYV(1,1)
      FRQSML=OSCIL(1)
      VELSML=VEL(1)
      RESSML=RESID(1)
      DO 616 I=2,NOFREQ
      IF(OSCIL(I)-FRQSML)611,612,612
  611 FRQSML=OSCIL(I)
  612 IF(VEL(I)-VELSML)613,614,614
  613 VELSML=VEL(I)
  614 IF(RESID(I)-RESSML)615,615,616
  615 RESSML=RESID(I)
  616 CONTINUE
      ORDSML=AMIN1(VELSML,RESSML)
C
C-------TO FIND THE LIMITS FOR THE (4X3) CYCLES------------
C
      IF(ALOG10(ORDSML))620,621,621
  620 LOGORD=ALOG10(ORDSML)-1.
      GO TO 622
  621 LOGORD=ALOG10(ORDSML)
  622 IF(ALOG10(FRQSML))623,624,624
  623 LOGFRQ=ALOG10(FRQSML)-1.
      GO TO 625
  624 LOGFRQ=ALOG10(FRQSML)
  625 ORDSML=10.**LOGORD
      ORDLG=ORDSML*10.**4
      FRQSML=10.**LOGFRQ
      FRQLG=FRQSML*10.**3
C-----PLOT LOG-LOG GRID FOR VELOCITY VS FREQUENCY-------
      CALL GRIDIV(1,FRQSML,FRQLG,ORDSML,ORDLG,1.0,1.0,1,1,1,1,-2,-2)
C-----TO FIND LARGEST 1X10 TO THE PTH POWER LINE FOR X--------
      OMSTRT=2.*PI*FRQSML
      TEMP=ALOG10(ORDLG/OMSTRT)
      IF(TEMP)627,628,628
  627 LOP=TEMP-1.
      GO TO 629
  628 LOP=TEMP
  629 D1=10.**LOP
      V1=OMSTRT*D1
      WIG=10.*ORDSML
      XMARGN=NXV(FRQLG)-NXV(FRQSML)
      YMARGN=NYV(ORDLG)-NYV(WIG)
      SLOPE=YMARGN/XMARGN
      IXCOR=4+NXV(FRQSML)
      CALL PRINTV(-1,1HD,IXCOR,NYV(V1))
      CALL PRINTV(-2,2HD=,900,17)
      CALL LABLV(D1,924,17,-2,1,3)
C------DRAW LINES UP FROM V1-----------
      VIS=0.
      DO 632 I=1,9
      VIS=VIS+V1
      IF(ORDLG-VIS)647,630,630
  630 XTCH=NYV(ORDLG)-NYV(VIS)
      ITCH=XTCH/SLOPE
      ITCH=NXV(FRQSML)+ITCH
```

```
                                                                    06/10/
        SNERD      -  EFN   SOURCE STATEMENT  -  IFN(S)  -

      KITCH=NYV(ORDLG)
      CALL LINEV (NXV(FROSML),NYV(VIS),ITCH,KITCH)
  632 CONTINUE
C-------DRAW LINES FROM V1 DOWN----------
  647 DO 638 J=1,20
      LAL=LOP-J
      LAN=LAL+1
      DLAN=10.**LAN
      DLAL=10.**LAL
      DO 638 I=1,9
      EFT1=I
      VIS=OMSTRT*DLAN-OMSTRT*DLAL*EFT1
      IF(VIS-ORDSML)639,633,633
  633 KITCH=NYV(ORDLG)-NYV(VIS)
      IYMARG=YMARGN
      IF(IYMARG-KITCH)635,634,634
  634 ZITCH=KITCH
      ITCH=ZITCH/SLOPE
      GO TO 637
  635 ITCH=XMARGN
      KITCH=YMARGN
  637 ITCH=ITCH+NXV(FROSML)
      KITCH=KITCH+NYV(VIS)
      CALL LINEV (NXV(FROSML),NYV(VIS),ITCH,KITCH)
  638 CONTINUE
C------DRAW FROM THE RIGHT ORDINATE THE REMAINING X-LINES------
  639 OMLAST=2.*PI*FROLG
      LEFT2=J
      LEFT1=EFT1
      DO 641 J=LEFT2,30
      LAL=LOP-J
      LAN=LAL+1
      DLAN=10.**LAN
      DLAL=10.**LAL
      DO 640 I=LEFT1,9
      EFT1=I
      VIS=OMLAST*DLAN-OMLAST*DLAL*EFT1
      IF(VIS-ORDSML)642,636,636
  636 KITCH=NYV(VIS)-NYV(ORDSML)
      CAPT=KITCH
      ITCH=CAPT/SLOPE
      ITCH=NXV(FROLG)-ITCH
      KITCH=NYV(ORDSML)
      CALL LINEV (NXV(FROLG),NYV(VIS), ITCH, KITCH)
  640 CONTINUE
      LEFT1=1
  641 CONTINUE
  642 CONTINUE
C---------PLOT POINTS-------
      CALL APLOTV(NOFREQ,OSCIL,VEL,1,1,1,44,LIT)
      IF(LIT)643,644,643
  643 WRITE(6,922) LIT,ALPHA(IX)
  644 GO TO (648,646),IALPHA
  648 CALL APLOTV(NOFREQ,OSCIL,RESID,1,1,1,38,KIT)
      CALL PRINTV(-28,28HOOO =RESIDUAL SHOCK SPECTRUM,NXV(FROSML),1006)
      IF(KIT)645,646,645
```

```
  645 WRITE(6,923) KIT,ALPHA(IX)
  646 CONTINUE
      CALL PRINTV(-15,15HFREQUENCY (CPS),452,6)
      CALL APRNTV(0,-14,-8,8HVELOCITY,9,576)
      CALL PRINTV(-8,8HALPHA=  ,20,17)
      CALL LABLV(ALPHA(IX),72,17,6,1,1)
      CALL PRINTV(-19,19H*** =SHOCK SPECTRUM,NXV(FRQSML),1015)
C------------GENERATION OF ACCELERATION GRID-------
C-----------TO FIND A1------------
      TEMP=ALOG10(ORDSML*OMSTRT)
      IF(TEMP)850,851,851
  850 LOP=TEMP
      GO TO 853
  851 LOP=TEMP+1.
  853 A1=10.**LOP
      V1=A1/OMSTRT
      CALL PRINTV(-1,1HA,IXCOR,NYV(V1))
      CALL PRINTV(-2,2HA=,900,4)
      CALL LABLV(A1,924,4,-2,1,3)
C------CRAW LINES DOWN FROM A1-------
      KITCH=NYV(ORDSML)
      DO 856 I=1,9
      EFT1=I-1
      VIS=V1*(1.-.1*EFT1)
      IF(ORDSML-VIS)855,855,857
  855 XTCH=NYV(VIS)-NYV(ORDSML)
      ITCH=XTCH/SLOPE
      ITCH=ITCH+NXV(FRQSML)
      CALL LINEV (NXV(FRQSML),NYV(VIS),ITCH, KITCH)
  856 CONTINUE
C--------DRAW LINES FROM A1 UP-------------
  857 DU 870 J=1,20
      LAN=LOP+J-1
      ALAN=10.**LAN
      DO 870 I=2,10
      EFT1=I
      VIS=ALAN/OMSTRT*EFT1
      IF(VIS-ORDLG)858,858,871
  858 KITCH=NYV(VIS)-NYV(ORDSML)
      IYMARG=YMARGN
      IF(IYMARG-KITCH)862,861,861
  861 ZITCH=KITCH
      ITCH=ZITCH/SLOPE
      KITCH=NYV(ORDSML)
      GO TO 868
  862 ITCH=XMARGN
      KITCH=NYV(VIS)-IYMARG
  868 ITCH=ITCH+NXV(FRQSML)
      CALL LINEV (NXV(FRQSML),NYV(VIS),ITCH, KITCH)
  870 CONTINUE
C--------CHAW FROM THE RIGHT ORDINATE ,REMAINING A-LINES---------
  871 LEFT2=J
      LEFT1=EFT1
      KITCH=NYV(ORDLG)
      DO 875 J=LEFT2,30
      LAN=LOP+J-1
```

```
                                                                    06/10/
        SNERD       -  EFN   SOURCE STATEMENT  -  IFN(S)  -

      ALAN=10.**LAN
      DO 874 I=LEFT1,10
      EFT1=I
      VIS=ALAN/OMLAST*EFT1
      IF(VIS-ORDLG)872,872,876
  872 CAPT=NYV(ORDLG)-NYV(VIS)
      ITCH=CAPT/SLOPE
      ITCH=NXV(FRQLG)-ITCH
      CALL LINEV (NXV(FRQLG),NYV(VIS), ITCH,KITCH)
  874 CONTINUE
      LEFT1=2
  875 CONTINUE
  876 CONTINUE
      GO TO 214
C
C------------SHORT FORM----------
  650 CONTINUE
      IF(ABS(FREQ-FREQ1)-.1E-04)651,651,652
  651 WRITE(8,912) ALPHA(IX)
  652 GO TO(658,655),IALPHA
  655 XOMAX=AMAX1(ABS(XMAX),ABS(XMIN))
      GO TO(668,669),IFREQ
  658 RMAX=SQRT(XOMEGA(KH)**2+XDOT(KH)**2)
      XOMAX=AMAX1(ABS(XMAX),ABS(XMIN),ABS(RMAX))
      GO TO(681,678),IFREQ
  668 WRITE(8,906) FREQ,XOMAX
      GO TO 215
  669 WRITE(8,905) FREQ,XOMAX
      GO TO 215
  678 WRITE(8,907) FREQ,XOMAX,RMAX
      GO TO 215
  681 WRITE(8,908) FREQ,XOMAX,RMAX
      GO TO 215
C
C---------LONG FORM---------
  700 CONTINUE
      IF(ABS(FREQ-FREQ1)-.1E-04)701,701,702
  701 WRITE(6,915) ALPHA(IX)
  702 GO TO(704,705),IALPHA
  704 RMAX=SQRT(XOMEGA(KH)**2+XDOT(KH)**2)
      GO TO(743,742),IFREQ
  705 GO TO(726,727),IFREQ
  726 WRITE(6,916) FREQ,XMAX,XMIN
      GO TO 785
  727 WRITE(6,910) FREQ,XMAX,XMIN
      GO TO 785
  742 WRITE(6,910) FREQ,XMAX,XMIN,RMAX
      GO TO 785
  743 WRITE(6,911) FREQ,XMAX,XMIN,RMAX
      GO TO 785
C
C--------PRELIMINARY CALCULATIONS FOR MIN. AND MAX. RESPONSE----------
  756 GO TO (758,757),IALPHA
  757 NX=N
      GO TO 759
  758 NX=KH
```

```
          SNERD        - EFN   SOURCE STATEMENT  -  IFN(S)  -

  759 XMAX=XOMEGA(1)
      KMX=1
      XMIN=XOMEGA(1)
      KMN=1
      DO 760 I=2,NX
      IF(XMAX-XOMEGA(I))761,762,762
  761 XMAX=XOMEGA(I)
      KMX=I
  762 IF(XMIN-XOMEGA(I))760,765,765
  765 XMIN=XOMEGA(I)
      KMN=I
  760 CONTINUE
      IF(KMX-1)771,770,771
  770 KMX=KMX+1
  771 IF(KMX-NX)773,772,773
  772 KMX=KMX-1
  773 IF(KMN-1)775,774,775
  774 KMN=KMN+1
  775 IF(KMN-NX)777,776,777
  776 KMN=KMN-1
  777 CONTINUE
      IF(XDOT(KMX-1)*XDOT(KMX))778,778,779
  778 KOOK=-1
      GO TO 781
  779 KOOK=0
  781 CONTINUE
      IF(XDOT(KMN-1)*XDOT(KMN))783,783,784
  783 KICK=-1
      GO TO 950
  784 KICK=0
  950 NIN=2
      GO TO 207
C
C-------EITHER RESTART WITH NEW FREQ. OR RESTART WITH NEW ALPHA OR STOP
  785 CONTINUE
      IF(ABS(FREQ-FREQ2)-.1E-03)800,755,755
  755 FREQ=FREQ+DELTAF
       GO TO 207
  800 CONTINUE
      GO TO 190
  801 WRITE(6,909)
      CALL FRAMEV
      STOP
C
  900 FORMAT(1H1,49X,22HSHOCK SPECTRUM PROGRAM//50X,21HAPPLIED MATH LAB
     1DTMB,///)
  901 FORMAT(40X,38HFOUNDATION ACCELERATION VS TIME(INPUT)//18X,23HFOUND
     1ATION ACCELERATION,36X,15HTIME IN SECONDS)
  902 FORMAT(42X,35HFOUNDATION VELOCITY VS TIME (INPUT)//20X,19HFOUNDATI
     1ON VELOCITY,35X,15HTIME IN SECONDS)
  903 FORMAT(1X,F35.9, 44X,F20.9)
  904 FORMAT(47H  PLOTTING ERROR NUMBER OF POINTS OUT OF RANGE=,I2//)
  905 FORMAT(15X,F10.5,29X,F12.7)
  906 FORMAT(10X,11HFIRST FREQ=,F10.5,7X,13HMAX RESPONSE=,F12.7/)
  907 FORMAT(15X,F10.5,2(29X,F12.7))
  908 FORMAT(10X,11HFIRST FREQ=,F10.5,7X,13HMAX RESPONSE=,F12.7,12X,
```

```
                                                                    06/10/
      SNERD        -  EFN   SOURCE STATEMENT  -  IFN(S)  -

   117HMAX RES RESPONSE=,F12.7)
909 FORMAT(///38X,25HPROGRAM RAN TO COMPLETION)
910 FORMAT(10X,F10.5,3(18X,F12.7))
911 FORMAT(5X,11HFIRST FREQ=,F10.5,9X,9HMAX RESP=,F12.7,10X,9HMIN RESP
   1=,F12.7,7X,15HMAX RESID RESP=,F12.7)
912 FORMAT(1H1,55X,10HSHORT FORM//45X,20HDAMPING COEFFICIENT=,F10.8///
   1/9X,22HFREQUENCY(CYCLES/SEC.),19X,20HMAX RESPONSE X OMEGA,18X,26HM
   2AX RESID RESPONSE X OMEGA)
913 FORMAT(59H  PLOTTING ERROR FOR X VS T, NUMBER OF POINTS OUT OF RAN
   1GE=,I2,6H FREQ=,F10.7//)
914 FORMAT(1X,I2,43H POINTS OUT OF RANGE FOR XDOT VS TIME,FREQ=,F10.7
   1//)
915 FORMAT(1H1,55X,9HLONG FORM//45X,20HDAMPING COEFFICIENT=,F10.8////
   17X,16HFREQ(CYCLES/SEC),12X,20HMAX RESPONSE X OMEGA,10X,20HMIN RESP
   2ONSE X OMEGA,8X,22HMAX RESID RESP X OMEGA)
916 FORMAT(4X,11HFIRST FREQ=,F10.5,10X,9HMAX RESP=,F12.7,10X,9HMIN RES
   1P=,F12.7)
917 FORMAT(1H1,18X,1HI,38X,4HS(I),34X,7HS2ND(I)//
   1(17X,I4,34X,F12.7,28X,F12.7))
918 FORMAT(1H1,50X,19HINTERMEDIATE VALUES/19X,1HI,35X,9HXOMEGA(I),
   131X,7HXDOT(I)//
   2(17X,I3,34X,F12.7,28X,F12.7))
919 FORMAT(1X,I2,43H POINTS OUT OF RANGE FOR Y    VS TIME,FREQ=,F10.7
   1//)
920 FORMAT(3F20.8)
921 FORMAT(6F15.6)
922 FORMAT(1X,I2,49H POINTS OUT OF RANGE FOR VEL VS. FREQ WITH ALPHA=,
   1F10.8)
923 FORMAT(1X,I2,50H POINTS OUT OF RANGE FOR RESIDUAL PLOT WITH ALPHA=
   1,  F10.8)
     END
```

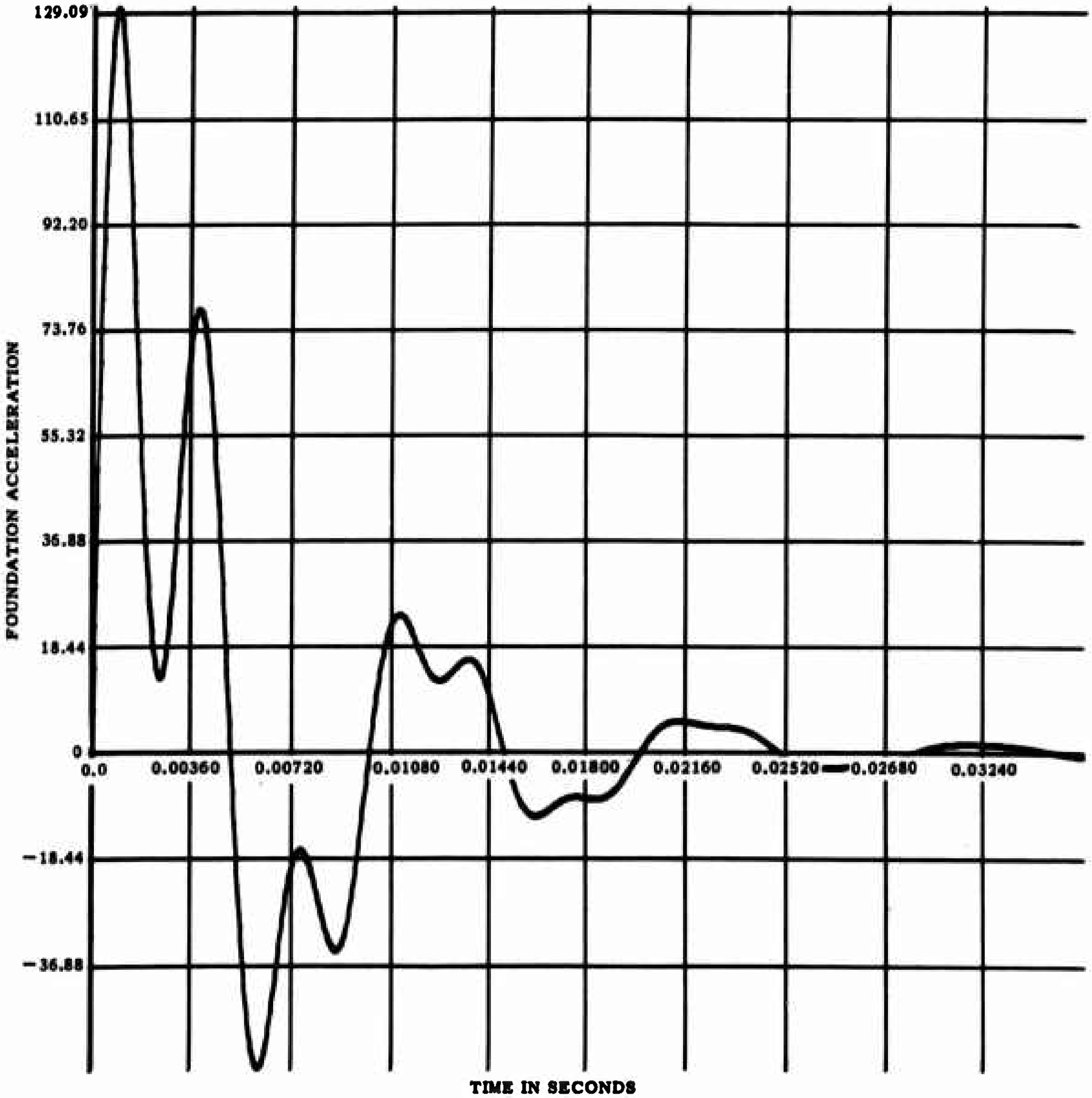


Figure 3 – Input Shock Function (Sample Problem 1)

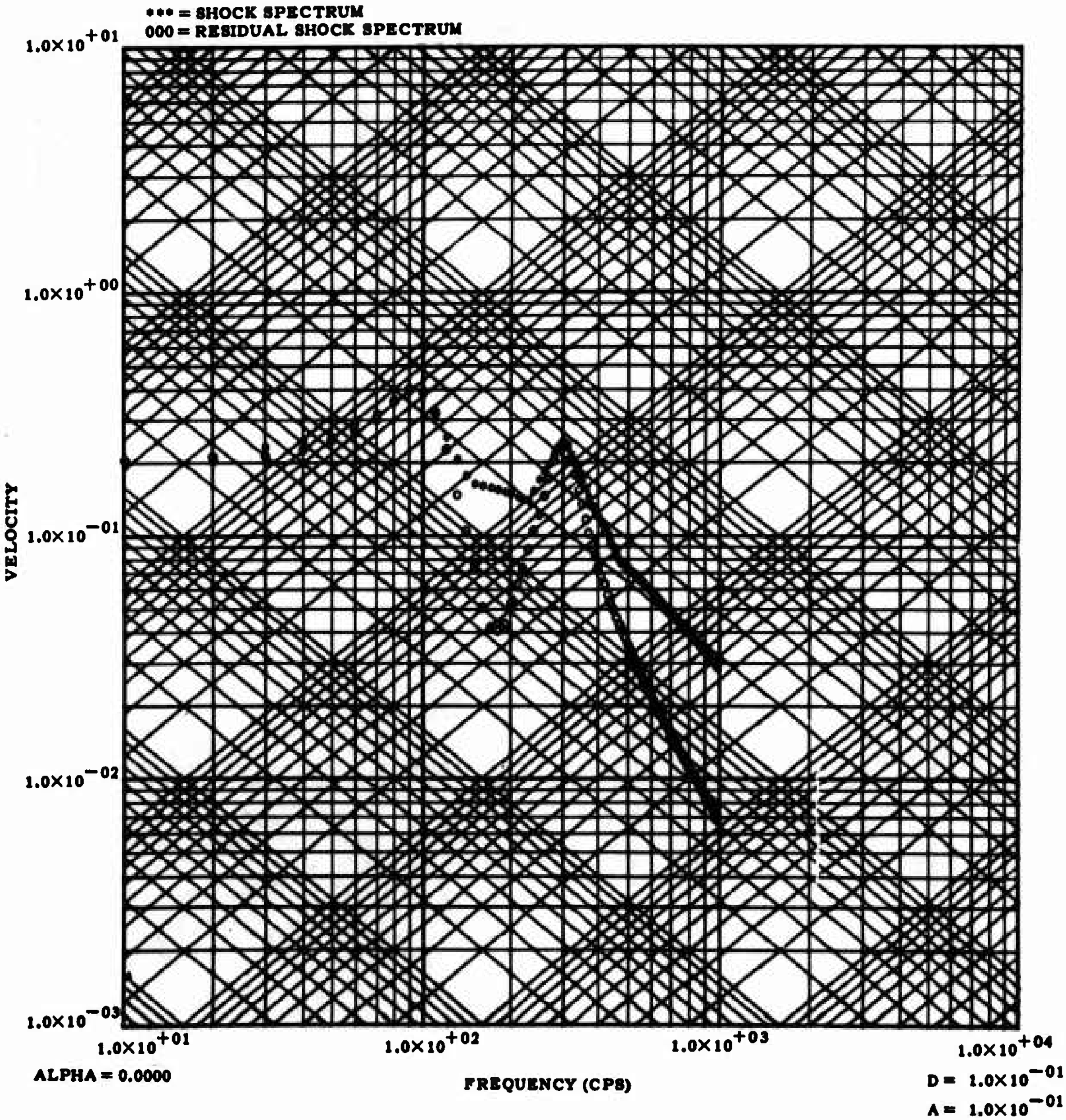


Figure 4 – Four-Coordinate Grid for Sample Problem 1, $\alpha = 0$

FREQUENCY RANGE = 10 TO 1000 CPS

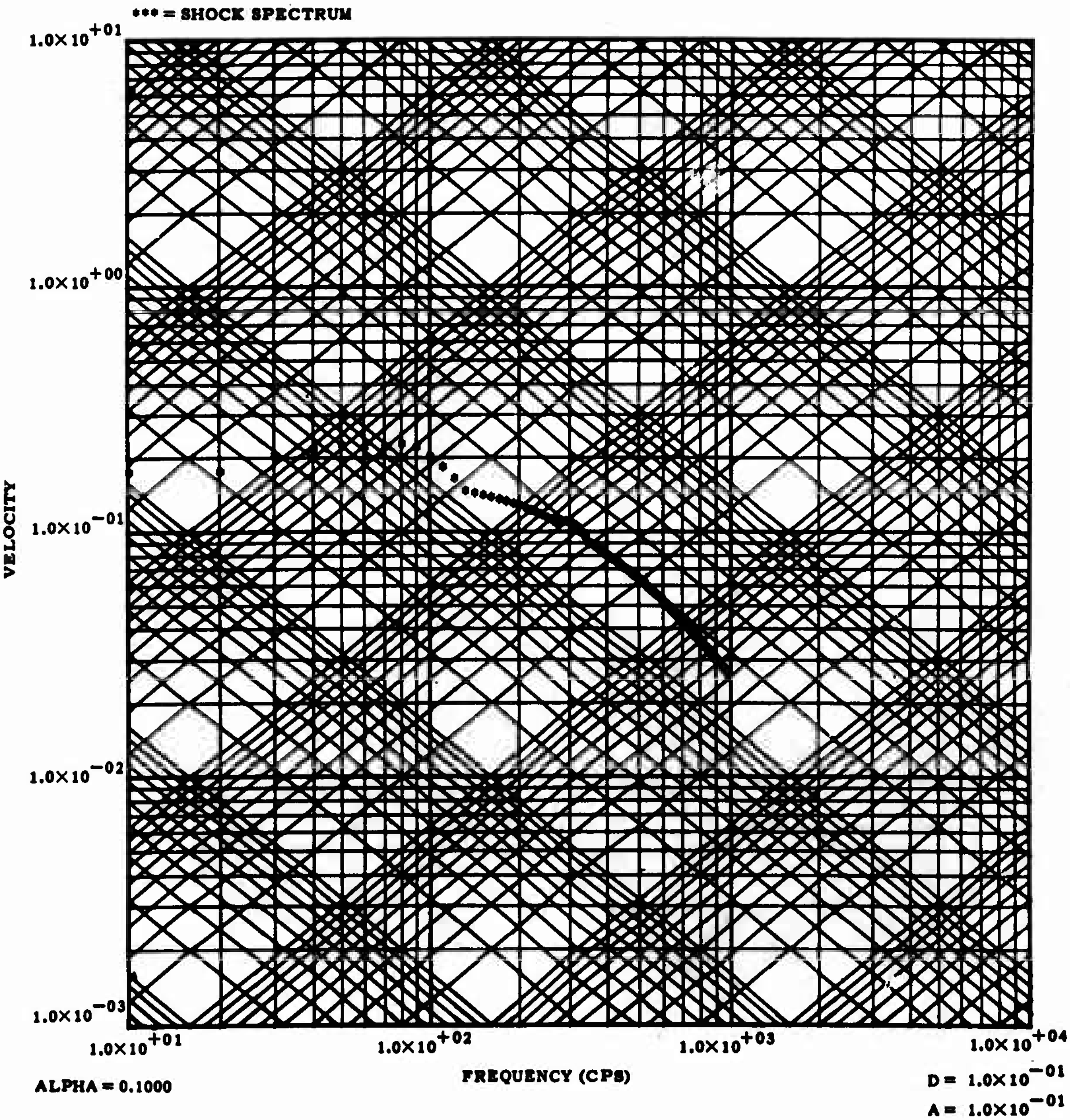


Figure 5 – Four-Coordinate Grid for Sample Problem 1, $\alpha = 0.1$

FREQUENCY RANGE = 10 TO 1000 CPS

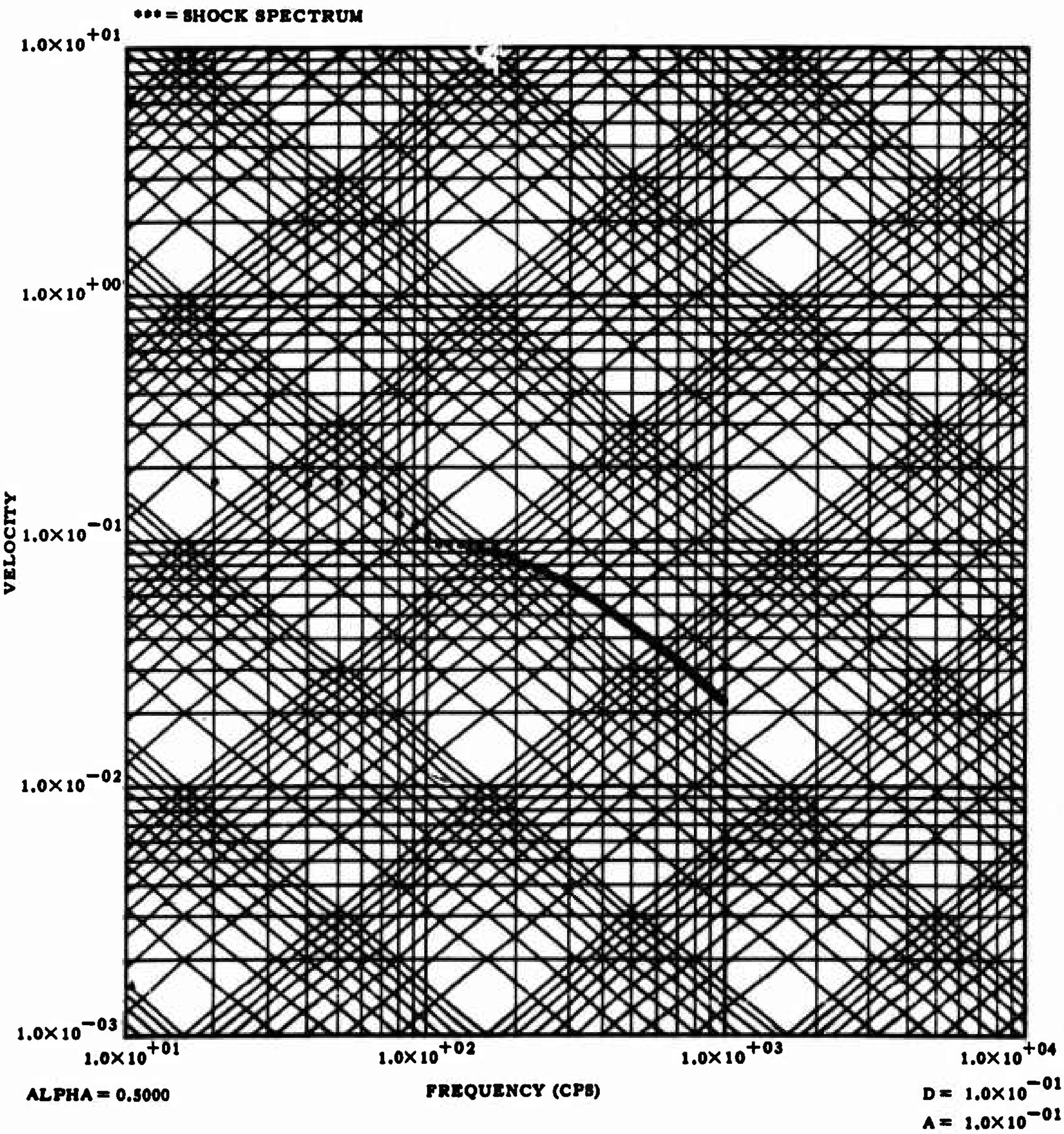


Figure 6 – Four-Coordinate Grid for Sample Problem 1, $\alpha = 0.5$

FREQUENCY RANGE = 10 TO 1000 CPS

TABULATION OF SHOCK FUNCTION FOR SAMPLE PROBLEM 1

SHOCK SPECTRUM PROGRAM

APPLIED MATH LAB DTMB

FOUNDATION ACCELERATION VS TIME(INPUT)

FOUNDATION ACCELERATION	TIME IN SECONDS
0.	0.
7.494259298	0.000029996
14.885627389	0.000060000
22.156842709	0.000089996
29.291196346	0.000119999
36.272578239	0.000149995
43.085520267	0.000179999
49.715232849	0.000209995
56.147649765	0.000239998
62.369453907	0.000269994
68.368118286	0.000299998
74.131931305	0.000329994
79.650019646	0.000359997
84.912377357	0.000389993
89.909880638	0.000419997
94.634310722	0.000449993
99.078365326	0.000479996
103.235664368	0.000510000
107.100768089	0.000539996
110.669174194	0.000569999
113.937322617	0.000599995
116.902592659	0.000629999
119.563299179	0.000659995
121.918684959	0.000689998
123.968916893	0.000719994
125.715063095	0.000749998
127.159080505	0.000779994
128.303802490	0.000809997
129.152914047	0.000839993
129.710926056	0.000869997
129.983152390	0.000899993
129.975681305	0.000929996
129.695352554	0.000960000
129.149709702	0.000989996
128.346982956	0.001019999
127.296045303	0.001049995
126.006376266	0.001079999
124.488022804	0.001109995
122.751562119	0.001139998
120.808059692	0.001169994
118.669028282	0.001199998
116.346379280	0.001229994
113.852384567	0.001259997
111.199636459	0.001289994
108.400992393	0.001319997
105.469536781	0.001349993
102.418532372	0.001379997
99.261381149	0.001409993
96.011573791	0.001439996
92.682648659	0.001470000
89.288141251	0.001499996

PRINTOUT OF FIRST AND SECOND FORWARD DIFFERENCE FOR SAMPLE PROBLEM 1

I	S(I) s_n	S2ND(I) s_n^2
1	7.4942593	-0.1028912
2	7.3913681	-0.1028912
3	7.2712153	-0.1201528
4	7.1343536	-0.1368617
5	6.9813819	-0.1529717
6	6.8129420	-0.1684399
7	6.6297126	-0.1832294
8	6.4324169	-0.1972957
9	6.2218041	-0.2106128
10	5.9986644	-0.2231398
11	5.7638130	-0.2348514
12	5.5180883	-0.2457247
13	5.2623577	-0.2557306
14	4.9975033	-0.2648544
15	4.7244301	-0.2730732
16	4.4440546	-0.2803755
17	4.1572990	-0.2867556
18	3.8651037	-0.2921953
19	3.5684061	-0.2966976
20	3.2681484	-0.3002577
21	2.9652700	-0.3028784
22	2.6607065	-0.3045635
23	2.3553858	-0.3053207
24	2.0502319	-0.3051538
25	1.7461462	-0.3040857
26	1.4440174	-0.3021288
27	1.1447220	-0.2992954
28	0.8491116	-0.2956104
29	0.5580120	-0.2910995
30	0.2722263	-0.2857857
31	-0.0074711	-0.2796974
32	-0.2803288	-0.2728577
33	-0.5456429	-0.2653141
34	-0.8027267	-0.2570839
35	-1.0509377	-0.2482109
36	-1.2896690	-0.2387314
37	-1.5183535	-0.2286844
38	-1.7364607	-0.2181072
39	-1.9435024	-0.2070417
40	-2.1390314	-0.1955290
41	-2.3226490	-0.1836176
42	-2.4939947	-0.1713457
43	-2.6527481	-0.1587534
44	-2.7986441	-0.1458960
45	-2.9314556	-0.1328115
46	-3.0510044	-0.1195488
47	-3.1571512	-0.1061468
48	-3.2498074	-0.0926561
49	-3.3289251	-0.0791178
50	-3.3945074	-0.0655823
51	-3.4465914	-0.0520840
52	-3.4852648	-0.0386734
53	-3.5106516	-0.0253868
54	-3.5229206	-0.0122690
55	-3.5222807	0.0006399
56	-3.5089779	0.0133028
57	-3.4832954	0.0256824

SAMPLE PROBLEM 1

SHORT FORM

DAMPING COEFFICIENT=0.

FREQUENCY(CYCLES/SEC.)	MAX RESPONSE X OMEGA	MAX RESID RESPONSE X OMEGA
10.00000	0.2075925	0.2075925
20.00000	0.2135596	0.2135596
30.00000	0.2343271	0.2155445
40.00000	0.2502408	0.2291704
50.00000	0.2570506	0.2515084
60.00000	0.2953460	0.2703295
70.00000	0.3229052	0.3027342
80.00000	0.3642787	0.3592854
90.00000	0.4029435	0.4029435
100.00000	0.3924811	0.3924702
110.00000	0.3254382	0.3231374
120.00000	0.2562569	0.2271617
130.00000	0.2091988	0.1487625
140.00000	0.1790675	0.1048990
150.00000	0.1643858	0.0749400
160.00000	0.1612755	0.0509474
170.00000	0.1581949	0.0422647
180.00000	0.1551050	0.0407670
190.00000	0.1519937	0.0432611
200.00000	0.1488608	0.0528501
210.00000	0.1457131	0.0632112
220.00000	0.1425598	0.0739499
230.00000	0.1394123	0.0882626
240.00000	0.1534851	0.1049084
250.00000	0.1715474	0.1234198
260.00000	0.1858054	0.1461594
270.00000	0.1961755	0.1739952
280.00000	0.2170798	0.2043399
290.00000	0.2341621	0.2303319
300.00000	0.2435210	0.2422168
310.00000	0.2355280	0.2340409
320.00000	0.2170148	0.2097559
330.00000	0.1994641	0.1808549
340.00000	0.1809882	0.1559875
350.00000	0.1691856	0.1353168
360.00000	0.1576531	0.1173742
370.00000	0.1455097	0.1033586
380.00000	0.1330372	0.0926164
390.00000	0.1263987	0.0829031
400.00000	0.1202743	0.0746132
410.00000	0.1140373	0.0684170
420.00000	0.1077678	0.0627957
430.00000	0.1015282	0.0573923
440.00000	0.0953766	0.0532774
450.00000	0.0893573	0.0498082
460.00000	0.0835054	0.0461208
470.00000	0.0786324	0.0430616
480.00000	0.0768374	0.0407508
490.00000	0.0750938	0.0382173
500.00000	0.0734003	0.0357994
510.00000	0.0717556	0.0340908
520.00000	0.0701580	0.0323615

530.00000	0.0686067	0.0304324
540.00000	0.0671016	0.0290216
550.00000	0.0656381	0.0278279
560.00000	0.0642174	0.0263308
570.00000	0.0628369	0.0250788
580.00000	0.0614966	0.0242022
590.00000	0.0601925	0.0230925
600.00000	0.0589277	0.0219662
610.00000	0.0576980	0.0212421
620.00000	0.0565023	0.0204536
630.00000	0.0553399	0.0194742
640.00000	0.0542099	0.0188002
650.00000	0.0531115	0.0182437
660.00000	0.0520436	0.0174431
670.00000	0.0510052	0.0167792
680.00000	0.0499952	0.0163568
690.00000	0.0490126	0.0157489
700.00000	0.0480562	0.0151047
710.00000	0.0471248	0.0147314
720.00000	0.0462192	0.0142986
730.00000	0.0453384	0.0137106
740.00000	0.0444796	0.0133310
750.00000	0.0436436	0.0130285
760.00000	0.0428304	0.0125353
770.00000	0.0420361	0.0121315
780.00000	0.0412653	0.0119004
790.00000	0.0405114	0.0115235
800.00000	0.0397796	0.0111103
810.00000	0.0390637	0.0108952
820.00000	0.0383680	0.0106305
830.00000	0.0376886	0.0102409
840.00000	0.0370256	0.0100050
850.00000	0.0363806	0.0098248
860.00000	0.0357503	0.0094932
870.00000	0.0351346	0.0092256
880.00000	0.0345360	0.0090892
890.00000	0.0339510	0.0088363
900.00000	0.0333794	0.0085508
910.00000	0.0328210	0.0084178
920.00000	0.0322770	0.0082439
930.00000	0.0317460	0.0079684
940.00000	0.031[illegible]71	0.0078115
950.00000	0.0307201	0.0076976
960.00000	0.0302247	0.0074609
970.00000	0.0297405	0.0072728
980.00000	0.0292675	0.0071882
990.00000	0.0288051	0.0070088
1000.00000	0.0283533	0.0068009

SAMPLE PROBLEM 1

SHORT FORM

DAMPING COEFFICIENT=0.09999999

FREQUENCY(CYCLES/SEC.)	MAX RESPONSE X OMEGA	MAX RESID RESPONSE X OMEGA
10.00000	0.1776276	
20.00000	0.1780555	
30.00000	0.2061876	
40.00000	0.2189432	
50.00000	0.2272549	
60.00000	0.2247007	
70.00000	0.2235191	
80.00000	0.2313129	
90.00000	0.2230218	
100.00000	0.2055132	
110.00000	0.1856178	
120.00000	0.1664997	
130.00000	0.1479188	
140.00000	0.1448784	
150.00000	0.1422331	
160.00000	0.1396128	
170.00000	0.1369228	
180.00000	0.1342103	
190.00000	0.1314370	
200.00000	0.1286957	
210.00000	0.1259278	
220.00000	0.1231618	
230.00000	0.1203831	
240.00000	0.1176854	
250.00000	0.1149960	
260.00000	0.1123324	
270.00000	0.1096743	
280.00000	0.1108744	
290.00000	0.1115363	
300.00000	0.1106187	
310.00000	0.1083103	
320.00000	0.1047713	
330.00000	0.1002521	
340.00000	0.0948905	
350.00000	0.0906852	
360.00000	0.0885652	
370.00000	0.0864970	
380.00000	0.0844803	
390.00000	0.0825163	
400.00000	0.0806307	
410.00000	0.0787856	
420.00000	0.0769749	
430.00000	0.0752161	
440.00000	0.0735363	
450.00000	0.0718776	
460.00000	0.0702592	
470.00000	0.0687198	
480.00000	0.0671860	
490.00000	0.0657257	
500.00000	0.0642945	
510.00000	0.0628962	
520.00000	0.0615577	

530.00000	0.0602275
540.00000	0.0589708
550.00000	0.0577126
560.00000	0.0565262
570.00000	0.0553420
580.00000	0.0542143
590.00000	0.0531050
600.00000	0.0520244
610.00000	0.0509895
620.00000	0.0499450
630.00000	0.0489834
640.00000	0.0480091
650.00000	0.0470742
660.00000	0.0461730
670.00000	0.0452627
680.00000	0.0444191
690.00000	0.0435803
700.00000	0.0427374
710.00000	0.0419653
720.00000	0.0411892
730.00000	0.0404089
740.00000	0.0396957
750.00000	0.0389812
760.00000	0.0382637
770.00000	0.0375924
780.00000	0.0369375
790.00000	0.0362804
800.00000	0.0356375
810.00000	0.0350391
820.00000	0.0344396
830.00000	0.0338395
840.00000	0.0332677
850.00000	0.0327227
860.00000	0.0321773
870.00000	0.0316322
880.00000	0.0311124
890.00000	0.0306184
900.00000	0.0301246
910.00000	0.0296315
920.00000	0.0291500
930.00000	0.0287008
940.00000	0.0282555
950.00000	0.0278112
960.00000	0.0273684
970.00000	0.0269470
980.00000	0.0265456
990.00000	0.0261465
1000.00000	0.0257489

SAMPLE PROBLEM 1

SHORT FORM

DAMPING COEFFICIENT=0.50000000

FREQUENCY(CYCLES/SEC.)	MAX RESPONSE X OMEGA	MAX RESID RESPONSE X OMEGA
10.00000	0.6950034	
20.00000	0.1763736	
30.00000	0.1379774	
40.00000	0.1735566	
50.00000	0.1741854	
60.00000	0.1608198	
70.00000	0.1449970	
80.00000	0.1296580	
90.00000	0.1157120	
100.00000	0.1051645	
110.00000	0.0972676	
120.00000	0.0983294	
130.00000	0.0974357	
140.00000	0.0958716	
150.00000	0.0940406	
160.00000	0.0919184	
170.00000	0.0898399	
180.00000	0.0877381	
190.00000	0.0856670	
200.00000	0.0836305	
210.00000	0.0816244	
220.00000	0.0797440	
230.00000	0.0778310	
240.00000	0.0760546	
250.00000	0.0743176	
260.00000	0.0726249	
270.00000	0.0709796	
280.00000	0.0693832	
290.00000	0.0678357	
300.00000	0.0663363	
310.00000	0.0648832	
320.00000	0.0634738	
330.00000	0.0621053	
340.00000	0.0607742	
350.00000	0.0594771	
360.00000	0.0582832	
370.00000	0.0571080	
380.00000	0.0559890	
390.00000	0.0548891	
400.00000	0.0538074	
410.00000	0.0527769	
420.00000	0.0517548	
430.00000	0.0507732	
440.00000	0.0498104	
450.00000	0.0488764	
460.00000	0.0479668	
470.00000	0.0470820	
480.00000	0.0462190	
490.00000	0.0453841	
500.00000	0.0445610	
510.00000	0.0437756	
520.00000	0.0429922	

530.00000	0.0422488
540.00000	0.0415147
550.00000	0.0407960
560.00000	0.0401094
570.00000	0.0394272
580.00000	0.0387682
590.00000	0.0381315
600.00000	0.0375004
610.00000	0.0368902
620.00000	0.0363021
630.00000	0.0357199
640.00000	0.0351486
650.00000	0.0346066
660.00000	0.0340708
670.00000	0.0335417
680.00000	0.0330308
690.00000	0.0325383
700.00000	0.0320525
710.00000	0.0315734
720.00000	0.0311087
730.00000	0.0306628
740.00000	0.0302233
750.00000	0.0297905
760.00000	0.0293645
770.00000	0.0289568
780.00000	0.0285598
790.00000	0.0281691
800.00000	0.0277848
810.00000	0.0274071
820.00000	0.0270399
830.00000	0.0266872
840.00000	0.0263405
850.00000	0.0259998
860.00000	0.0256651
870.00000	0.0253364
880.00000	0.0250138
890.00000	0.0247045
900.00000	0.0244022
910.00000	0.0241054
920.00000	0.0238140
930.00000	0.0235280
940.00000	0.0232475
950.00000	0.0229723
960.00000	0.0227025
970.00000	0.0224402
980.00000	0.0221862
990.00000	0.0219369
1000.00000	0.0216923

SAMPLE PROBLEM 1

LONG FORM

DAMPING COEFFICIENT=0.

FREQ(CYCLES/SEC)	MAX RESPONSE X OMEGA	MIN RESPONSE X OMEGA	MAX RESID RESP X OMEGA
10.00000	0.0000029	-0.2065533	0.2075925
20.00000	0.1116289	-0.2051239	0.2135596
30.00000	0.2187229	-0.2343271	0.2155445
40.00000	0.2258621	-0.2502408	0.2291704
50.00000	0.2501398	-0.2570506	0.2515084
60.00000	0.2953460	-0.2689953	0.2703295
70.00000	0.3222017	-0.3229052	0.3027342
80.00000	0.3642787	-0.3611291	0.3592854
90.00000	0.3901918	-0.3990324	0.4029435
100.00000	0.3924811	-0.3852212	0.3924702
110.00000	0.3254382	-0.3252005	0.3231374
120.00000	0.2525802	-0.2562569	0.2271617
130.00000	0.2091988	-0.2025897	0.1487625
140.00000	0.1790675	-0.1676214	0.1048990
150.00000	0.1470611	-0.1643858	0.0749400
160.0000C	0.1139742	-0.1612755	0.0509474
170.00000	0.0813069	-0.1581949	0.0422647
180.00000	0.0587927	-0.1551050	0.0407670
190.00000	0.0592988	-0.1519937	0.0432611
200.00000	0.0645984	-0.1488608	0.0528501
210.00000	0.0812001	-0.1457131	0.0632112
220.00000	0.1074940	-0.1425598	0.0739499
230.00000	0.1319333	-0.1394123	0.0882626
240.00000	0.1534851	-0.1362791	0.1049084
250.00000	0.1715474	-0.1377802	0.1234198
260.00000	0.1858054	-0.1685959	0.1461594
270.00000	0.1961755	-0.1961367	0.1739952
280.00000	0.2135826	-0.2170798	0.2043399
290.00000	0.2341621	-0.2336592	0.2303319
300.00000	0.2435210	-0.2433512	0.2422168
310.00000	0.2350194	-C.2355280	0.2340409
320.00000	0.2170148	-0.2169204	0.2097559
330.00000	0.1949258	-0.1994641	0.1808549
340.00000	0.1809882	-0.1781675	0.1559875
350.00000	0.1691856	-0.1548310	0.1353168
360.00000	0.1576531	-0.1431226	0.1173742
370.00000	0.1455097	-0.1379343	0.1033586
380.00000	0.1330372	-0.1323195	0.0926164
390.00000	0.1204784	-0.1263987	0.0829031
400.00000	0.1080442	-0.1202743	0.0746132
410.00000	0.0959097	-0.1140373	0.0684170
420.00000	0.0842173	-0.1077678	0.0627957
430.00000	0.0730873	-0.1015282	0.0573923
440.00000	0.0626136	-0.0953766	0.0532774
450.00000	0.0616163	-0.0893573	0.0498082
460.00000	0.0604020	-0.0835054	0.0461208
470.00000	0.0582525	-0.0786324	0.0430616
480.00000	0.0553163	-0.0768374	0.0407508
490.00000	0.0518079	-0.0750938	0.0382173
500.00000	0.0518449	-0.0734003	0.0357994
510.00000	0.0516743	-0.0717556	0.0340908
520.00000	0.0511100	-0.0701580	0.0323615

530.00000	0.0501319	-0.0686067	0.0304324
540.00000	0.0487503	-0.0671016	0.0290216
550.00000	0.0469985	-0.0656381	0.0278279
560.00000	0.0449161	-0.0642174	0.0263308
570.00000	0.0425542	-0.0628369	0.0250788
580.00000	0.0399636	-0.0614966	0.0242022
590.00000	0.0371952	-0.0601925	0.0230925
600.00000	0.0343024	-0.0589277	0.0219662
610.00000	0.0313290	-0.0576980	0.0212421
620.00000	0.0292234	-0.0565023	0.0204536
630.00000	0.0282349	-0.0553399	0.0194742
640.00000	0.0287046	-0.0542099	0.0188002
650.00000	0.0290982	-0.0531115	0.0182437
660.00000	0.0293745	-0.0520436	0.0174431
670.00000	0.0295037	-0.0510052	0.0167792
680.00000	0.0294687	-0.0499952	0.0163568
690.00000	0.0292600	-0.0490126	0.0157489
700.00000	0.0288793	-0.0480562	0.0151047
710.00000	0.0283285	-0.0471248	0.0147314
720.00000	0.0276182	-0.0462192	0.0142986
730.00000	0.0267598	-0.0453384	0.0137106
740.00000	0.0257684	-0.0444796	0.0133310
750.00000	0.0246569	-0.0436436	0.0130285
760.00000	0.0234453	-0.0428304	0.0125353
770.00000	0.0221469	-0.0420361	0.0121315
780.00000	0.0207801	-0.0412653	0.0119004
790.00000	0.0193588	-0.0405114	0.0115235
800.00000	0.0196544	-0.0397796	0.0111103
810.00000	0.0199283	-0.0390637	0.0108952
820.00000	0.0201358	-0.0383680	0.0106305
830.00000	0.0202630	-0.0376886	0.0102409
840.00000	0.0203082	-0.0370256	0.0100050
850.00000	0.0202632	-0.0363806	0.0098248
860.00000	0.0201299	-0.0357503	0.0094932
870.00000	0.0199066	-0.0351346	0.0092256
880.00000	0.0195985	-0.0345360	0.0090892
890.00000	0.0192060	-0.0339510	0.0088363
900.00000	0.0187363	-0.0333794	0.0085508
910.00000	0.0181950	-0.0328210	0.0084178
920.00000	0.0175868	-0.0322770	0.0082439
930.00000	0.0169189	-0.0317460	0.0079684
940.00000	0.0161975	-0.0312271	0.0078115
950.00000	0.0154303	-0.0307201	0.0076976
960.00000	0.0148083	-0.0302247	0.0074609
970.00000	0.0150021	-0.0297405	0.0072728
980.00000	0.0151531	-0.0292675	0.0071882
990.00000	0.0152592	-0.0288051	0.0070088
1000.00000	0.0153154	-0.0283533	0.0068009

SAMPLE PROBLEM 1

LONG FORM

DAMPING COEFFICIENT=0.09999999

FREQ(CYCLES/SEC)	MAX RESPONSE X OMEGA	MIN RESPONSE X OMEGA	MAX RESID RESP X OMEGA
10.00000	0.1390010	-0.1776276	
20.00000	0.1304883	-0.1780555	
30.00000	0.1385235	-0.2061876	
40.00000	0.1403955	-0.2189432	
50.00000	0.1639449	-0.2272549	
60.00000	0.2009101	-0.2247007	
70.00000	0.2235191	-0.2139103	
80.00000	0.2313129	-0.1986394	
90.00000	0.2230218	-0.2057401	
100.00000	0.2055132	-0.1939235	
110.00000	0.1856178	-0.1717686	
120.00000	0.1664997	-0.1504829	
130.00000	0.1479188	-0.1474850	
140.00000	0.1287061	-0.1448784	
150.00000	0.1086053	-0.1422331	
160.00000	0.0883387	-0.1396128	
170.00000	0.0693412	-0.1369228	
180.00000	0.0543430	-0.1342103	
190.00000	0.0478772	-0.1314370	
200.00000	0.0513437	-0.1286957	
210.00000	0.0603028	-0.1259278	
220.00000	0.0708280	-0.1231618	
230.00000	0.0811709	-0.1203831	
240.00000	0.0904891	-0.1176854	
250.00000	0.0982499	-0.1149960	
260.00000	0.1043048	-0.1123324	
270.00000	0.1085026	-0.1096743	
280.00000	0.1108744	-0.1071605	
290.00000	0.1115363	-0.1046330	
300.00000	0.1106187	-0.1021493	
310.00000	0.1083103	-0.0997299	
320.00000	0.1047713	-0.0973778	
330.00000	0.1002521	-0.0950990	
340.00000	0.0948905	-0.0928586	
350.00000	0.0888957	-0.0906852	
360.00000	0.0824535	-0.0885652	
370.00000	0.0757169	-0.0864970	
380.00000	0.0688093	-0.0844803	
390.00000	0.0618631	-0.0825163	
400.00000	0.0550025	-0.0806307	
410.00000	0.0483075	-0.0787856	
420.00000	0.0418508	-0.0769749	
430.00000	0.0357064	-0.0752161	
440.00000	0.0331957	-0.0735363	
450.00000	0.0313551	-0.0718776	
460.00000	0.0295201	-0.0702592	
470.00000	0.0276978	-0.0687198	
480.00000	0.0258992	-0.0671860	
490.00000	0.0241330	-0.0657257	
500.00000	0.0234211	-0.0642945	
510.00000	0.0240307	-0.0628962	
520.00000	0.0242630	-0.0615577	

530.00000	0.0241590	-0.0602275
540.00000	0.0237599	-0.0589708
550.00000	0.0231055	-0.0577126
560.00000	0.0222480	-0.0565262
570.00000	0.0212228	-0.0553420
580.00000	0.0200668	-0.0542143
590.00000	0.0188222	-0.0531050
600.00000	0.0175412	-0.0520244
610.00000	0.0162681	-0.0509895
620.00000	0.0150880	-0.0499450
630.00000	0.0141939	-0.0489834
640.00000	0.0141670	-0.0480091
650.00000	0.0144499	-0.0470742
660.00000	0.0147097	-0.0461730
670.00000	0.0148899	-0.0452627
680.00000	0.0149793	-0.0444191
690.00000	0.0149733	-0.0435803
700.00000	0.0148732	-0.0427374
710.00000	0.0146850	-0.0419653
720.00000	0.0144178	-0.0411892
730.00000	0.0140831	-0.0404089
740.00000	0.0136934	-0.0396957
750.00000	0.0132612	-0.0389812
760.00000	0.0127985	-0.0382637
770.00000	0.0123327	-0.0375924
780.00000	0.0118840	-0.0369375
790.00000	0.0115032	-0.0362804
800.00000	0.0112614	-0.0356375
810.00000	0.0111868	-0.0350391
820.00000	0.0111866	-0.0344396
830.00000	0.0111988	-0.0338395
840.00000	0.0111959	-0.0332677
850.00000	0.0111684	-0.0327227
860.00000	0.0111098	-0.0321773
870.00000	0.0110167	-0.0316322
880.00000	0.0108948	-0.0311124
890.00000	0.0107456	-0.0306184
900.00000	0.0105683	-0.0301246
910.00000	0.0103735	-0.0296315
920.00000	0.0101626	-0.0291500
930.00000	0.0099484	-0.0287008
940.00000	0.0097367	-0.0282558
950.00000	0.0095426	-0.0278112
960.00000	0.0093817	-0.0273684
970.00000	0.0092671	-0.0269470
980.00000	0.0091928	-0.0265456
990.00000	0.0091424	-0.0261465
1000.00000	0.0090997	-0.0257489

SAMPLE PROBLEM 1

LONG FORM

DAMPING COEFFICIENT=0.50000000

FREQ(CYCLES/SEC)	MAX RESPONSE X OMEGA	MIN RESPONSE X OMEGA	MAX RESID RESP X OMEGA
10.00000	0.6950034	-0.1557286	
20.00000	0.0173728	-0.1763736	
30.00000	0.0216063	-0.1379774	
40.00000	0.0242291	-0.1735566	
50.00000	0.0320474	-0.1741854	
60.00000	0.0516470	-0.1608198	
70.00000	0.0689969	-0.1449970	
80.00000	0.0754746	-0.1296580	
90.00000	0.0746953	-0.1157120	
100.00000	0.0701859	-0.1051645	
110.00000	0.0650796	-0.0972676	
120.00000	0.0598884	-0.0983294	
130.00000	0.0549674	-0.0974357	
140.00000	0.0513545	-0.0958716	
150.00000	0.0490710	-0.0940406	
160.00000	0.0476230	-0.0919184	
170.00000	0.0461552	-0.0898399	
180.00000	0.0447772	-0.0877381	
190.00000	0.0435280	-0.0856670	
200.00000	0.0424415	-0.0836305	
210.00000	0.0414751	-0.0816244	
220.00000	0.0406375	-0.0797440	
230.00000	0.0398612	-0.0778310	
240.00000	0.0391260	-0.0760546	
250.00000	0.0384056	-0.0743176	
260.00000	0.0376797	-0.0726249	
270.00000	0.0369335	-0.0709796	
280.00000	0.0361571	-0.0693832	
290.00000	0.0353439	-0.0678357	
300.00000	0.0345192	-0.0663363	
310.00000	0.0336519	-0.0648832	
320.00000	0.0327784	-0.0634738	
330.00000	0.0318833	-0.0621053	
340.00000	0.0309982	-0.0607742	
350.00000	0.0301269	-0.0594771	
360.00000	0.0292603	-0.0582832	
370.00000	0.0284058	-0.0571080	
380.00000	0.0275690	-0.0559890	
390.00000	0.0267536	-0.0548891	
400.00000	0.0259619	-0.0538074	
410.00000	0.0251945	-0.0527769	
420.00000	0.0244613	-0.0517548	
430.00000	0.0237594	-0.0507732	
440.00000	0.0230831	-0.0498104	
450.00000	0.0224462	-0.0488764	
460.00000	0.0218319	-0.0479668	
470.00000	0.0212543	-0.0470820	
480.00000	0.0207085	-0.0462190	
490.00000	0.0201738	-0.0453841	
500.00000	0.0196758	-0.0445610	
510.00000	0.0191975	-0.0437786	
520.00000	0.0187434	-0.0429922	

530.00000	0.0183129	-0.0422488
540.00000	0.0178993	-0.0415147
550.00000	0.0175021	-0.0407960
560.00000	0.0171275	-0.0401094
570.00000	0.0167681	-0.0394272
580.00000	0.0164223	-0.0387682
590.00000	0.0160897	-0.0381315
600.00000	0.0157717	-0.0375004
610.00000	0.0154689	-0.0368902
620.00000	0.0151769	-0.0363021
630.00000	0.0148953	-0.0357199
640.00000	0.0146237	-0.0351486
650.00000	0.0143615	-0.0346066
660.00000	0.0141109	-0.0340708
670.00000	0.0138701	-0.0335417
680.00000	0.0136372	-0.0330308
690.00000	0.0134119	-0.0325383
700.00000	0.0131939	-0.0320525
710.00000	0.0129827	-0.0315734
720.00000	0.0127782	-0.0311087
730.00000	0.0125801	-0.0306628
740.00000	0.0123905	-0.0302233
750.00000	0.0122065	-0.0297905
760.00000	0.0120279	-0.0293645
770.00000	0.0118544	-0.0289568
780.00000	0.0116859	-0.0285598
790.00000	0.0115221	-0.0281691
800.00000	0.0113629	-0.0277848
810.00000	0.0112080	-0.0274071
820.00000	0.0110573	-0.0270399
830.00000	0.0109106	-0.0266872
840.00000	0.0107688	-0.0263405
850.00000	0.0106312	-0.0259998
860.00000	0.0104971	-0.0256651
870.00000	0.0103664	-0.0253364
880.00000	0.0102388	-0.0250138
890.00000	0.0101145	-0.0247045
900.00000	0.0099931	-0.0244022
910.00000	0.0098746	-0.0241054
920.00000	0.0097589	-0.0238140
930.00000	0.0096460	-0.0235280
940.00000	0.0095356	-0.0232475
950.00000	0.0094277	-0.0229723
960.00000	0.0093223	-0.0227025
970.00000	0.0092192	-0.0224402
980.00000	0.0091184	-0.0221862
990.00000	0.0090205	-0.0219369
1000.00000	0.0089249	-0.0216923

PROGRAM RAN TO COMPLETION

APPENDIX B

SAMPLE PROBLEM 2

Arrangement of Input Data

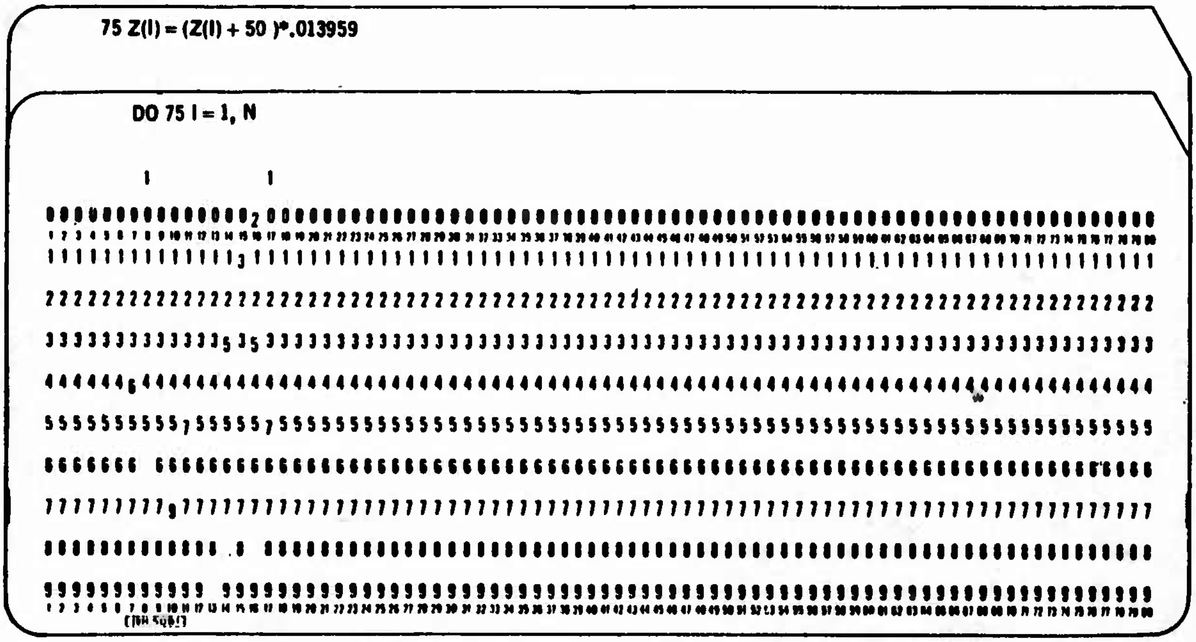
and

All the Various Forms of Output

That Can Be Generated

SAMPLE PROBLEM 2

The following example has a set of values for the foundation velocity $\dot{Z}$ as the input shock function; and the two following statements are inserted in the program to calibrate the $\dot{Z}$'s.



The data $\dot{Z}$ for this problem was furnished by George O'Hara of the Naval Research Laboratory.

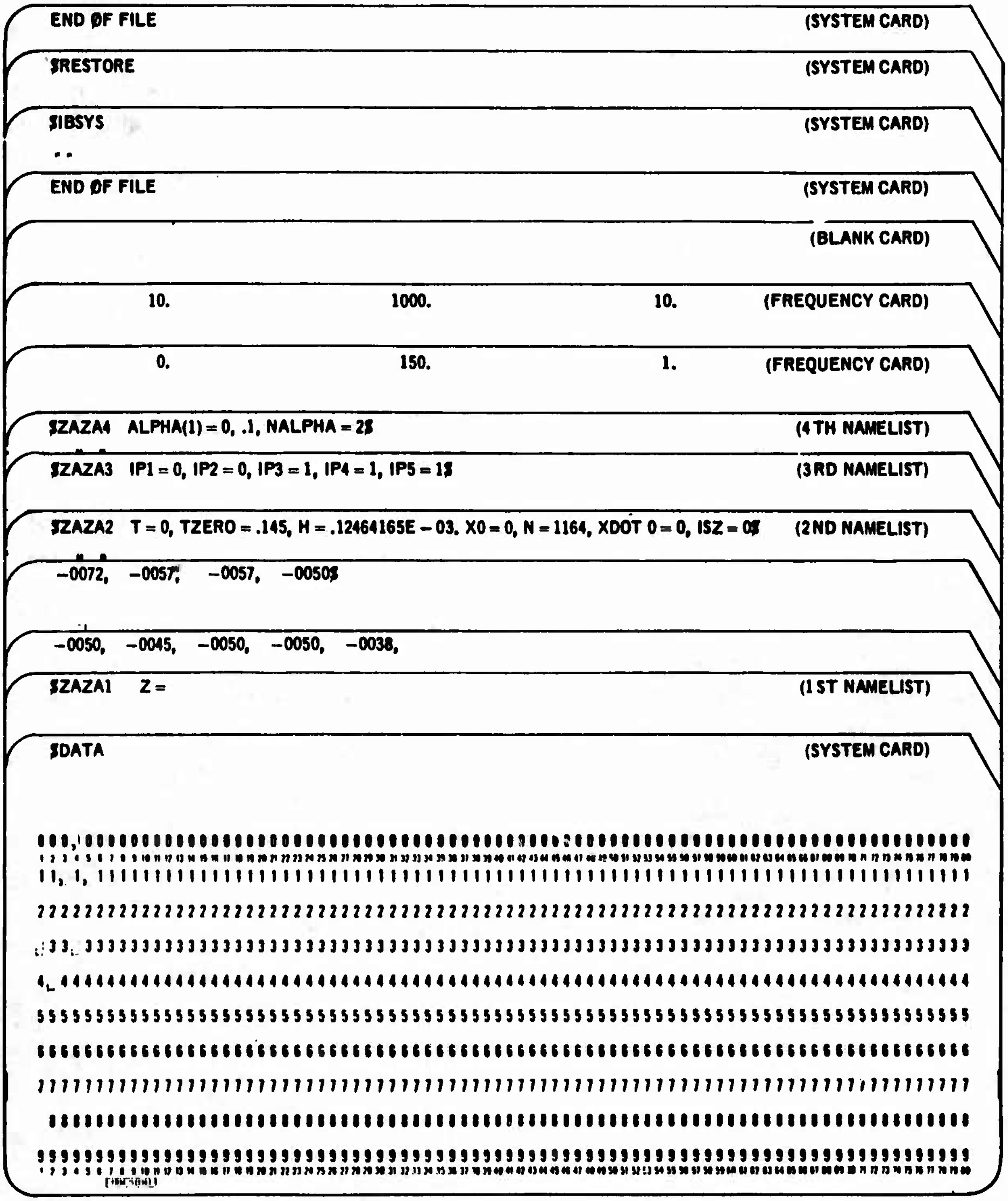


Figure 7 – Arrangement of Input Data for Sample Problem 2

NOTE: All the data cards for the first NAMELIST are not shown.

```
                                                                    06/10/66
        SNERD       -  EFN    SOURCE STATEMENT  -  IFN(S)  -

      DIMENSION Z(2000),T(2000),S(2000),S2ND(2000),XOMEGA(2000),X(2000),
     1XDOT(2000),ALPHA(25),OSCIL(1000) ,VEL(1000),RESID(1000)
      EQUIVALENCE (RESID,X(1)),(VEL,X(1001))
      NAMELIST/ZAZA1/Z/ZAZA2/T,TZERO,                    H,       X0,N,
     1XDOTO,ISZ/ZAZA3/IP1,IP2,IP3,IP4,IP5/ZAZA4/ALPHA,NALPHA
      WRITE(6,900)
      PI=3.1415927
      READ(5,ZAZA1)
      READ(5,ZAZA2)
      READ(5,ZAZA3)
      READ(5,ZAZA4)
      IF(IP3)50,51,50
   50 IP1=0
      IP2=0
   51 CONTINUE
      DO 75 I=1,N
   75 Z(I)=(Z(I)+50.)*.013959
C
C------------WRITE AND PLOT INPUT DATA--------------
      DO 100 I=2,N
  100 T(I)=T(I-1)+H
      IF(ISZ)104,105,104
  104 WRITE(6,901)
      GO TO 106
  105 WRITE(6,902)
  106 CONTINUE
      WRITE(6,903) (Z(I),T(I),I=1,N)
      ZMIN=Z(1)
      ZMAX=Z(1)
      DO 110 I=2,N
      IF(ZMAX-Z(I))108,109,109
  108 ZMAX=Z(I)
      GO TO 110
  109 IF(ZMIN-Z(I))110,110,107
  107 ZMIN=Z(I)
  110 CONTINUE
      CALL CAMRAV(35)
      ZN=N
      DX=H*ZN/10.
      DY=(ZMAX-ZMIN)/10.
      CALL GRIDIV(1,T(1),T(N),ZMIN,ZMAX,DX,DY,1,1,1,1,6,6)
      CALL APLOTV(N,T,Z,1,1,1,42,IERR)
      IF(IERR)115,116,115
  115 WRITE(6,904) IERR
  116 CONTINUE
      NN=N-1
      DO 120 I=1,NN
      CALL LINEV(NXV(T(I)),NYV(Z(I)),NXV(T(I+1)),NYV(Z(I+1)))
  120 CONTINUE
      CALL PRINTV(-15,15HTIME IN SECONDS,452,6)
      IF(ISZ)121,122,121
  121 CALL APRNTV(0,-14,-23,23HFOUNDATION ACCELERATION,4,696)
      GO TO 123
  122 CALL APRNTV(0,-14,-19,19HFOUNDATION VELOCITY,4,664)
  123 CONTINUE
```

```
C
C----------COMPUTE S(N) AND S2ND(N) FOR EACH TIME,T--------
      S(1)=Z(2)-Z(1)
      S2ND(1)=Z(3)-2.*Z(2)+Z(1)
       K=N-1
      DO 200 I=2,K
      S(I)=Z(I+1)-Z(I)
  200 S2ND(I)=Z(I+1)-2.*Z(I)+Z(I-1)
      WRITE(6,917) (I,S(I),S2ND(I),I=1,N)
C
  190 READ(5,920) FREQ1,FREQ2,DELTAF
      IF(ABS(FREQ1-FREQ2)-.1E-20) 801,801,191
  191 CONTINUE
      IF(IP3)192,195,192
  192 TEMP=FREQ2-FREQ1
      IF(AMOD(TEMP,DELTAF)-DELTAF/2.)193,194,194
  193 NOFREQ=TEMP/DELTAF
      GO TO 195
  194 NOFREQ=TEMP/DELTAF+1.0001
  195 CONTINUE
C------DAMPED OR UNDAMPED,IF UNDAMPED FIND NUMBER OF RESIDUAL POINTS---------
      DO 800 IX=1,NALPHA
      NIN=1
      INI=0
      FREQ=FREQ1
      IF(ABS(ALPHA(IX))-.1E-09)201,201,202
  201 IALPHA=1
      GO TO 222
  202 IALPHA=2
  222 GO TO (203,207),IALPHA
  203 TT=TZERO-T(1)
       IF(AMOD(TT,H)-H/2.)205,204,204
  204 KH=TT/H+1.000001
      GO TO 207
  205 KH=TT/H+.000001
  207 CONTINUE
C
C---------COMPUTE CONSTANTS-------
      OMEGA=FREQ*2.*PI
      RADCAL=SQRT(1.-ALPHA(IX)**2)
      OH=OMEGA*H
      P=OMEGA*RADCAL
      EX=EXP(-ALPHA(IX)*OH)
      COSPH=COS(P*H)
      SINPH=SIN(P*H)
      A2OH=2.*ALPHA(IX)/OH
      RECOH=1./OH
       ALPHA2=ALPHA(IX)**2
      X12=1.-2.*ALPHA2
      FACT1=EX*SINPH/RADCAL
      FACT2=EX*COSPH+FACT1*ALPHA(IX)
      IF(ABS(FREQ)-.1E-20)220,220,221
  220 IFREQ=1
      GO TO 223
  221 IFREQ=2
  223 IF(ISZ)300,208,300
```

```
  208 GO TO (400,209),IFREQ
  209 CONTINUE
C
C------COMPUTEXOMEGA(N),XDOT FOR VELOCITY INPUT------------
      FACT3=RECOH*(1.-FACT2)
      FACT4=RECOH*(.5-2.*ALPHA(IX)*RECOH+EX*((.5+2.*ALPHA(IX)*RECOH)
     1*COSPH-(X12*RECOH-ALPHA(IX)/2.)*SINPH/RADCAL))
      FACT5=EX*COSPH-ALPHA(IX)*FACT1
      FACT6=RECOH*FACT1
      FACT7=(RECOH**2)*(1.-EX*(COSPH+(ALPHA(IX)+OH/2.)*SINPH/RADCAL))
      GO TO(224,225),NIN
  224 XOMEGA(1)=OMEGA*XO
      XDOT(1)=XDOTO
      DO 210 I=2,K
      XOMEGA(I)=XOMEGA(I-1)*FACT2+XDOT(I-1)*FACT1-S(I-1)*FACT3-S2ND(I-1)
     1*FACT4
  210 XDOT(I)=-XOMEGA(I-1)*FACT1+XDOT(I-1)*FACT5-S(I-1)*FACT6-S2ND(I-1)*
     1FACT7
       GO TO 756
  225 CONTINUE
      KRO=KMX+KOOK
      KRA=KMN+KICK
      DO 235 I=2,5
      VA=I-1
      TA=VA*.2*H
      COSPT=COS(P*TA)
      SINPT=SIN(P*TA)
      EXT=EXP(-ALPHA(IX)*OMEGA*TA)
      FACTR1=EXT*(COSPT+ALPHA(IX)*SINPT/RADCAL)
      FACTR2=EXT*SINPT/RADCAL
      FACTR3=(1.-FACTR1)*RECOH
      FACTR4=(TA/H-.5-A2OH+(ALPHA(IX)/2.-X12*RECOH)*FACTR2+(.5+A2OH)
     1*EXT*COSPT)*RECOH
      XMAXO    =XOMEGA(KRO)*FACTR1+XDOT(KRO)*FACTR2-S(KRO)*FACTR3
     1-S2ND(KRO)*FACTR4
      IF(XMAX-XMAXO    )229,230,230
  229 XMAX=XMAXO
  230 XMINO    =XOMEGA(KRA)*FACTR1+XDOT(KRA)*FACTR2-S(KRA)*FACTR3
     1-S2ND(KRA)*FACTR4
      IF(XMIN-XMINO    )235,235,232
  232 XMIN=XMINO
  235 CONTINUE
      NIN=1
  211 IF(IP1)500,212,500
  212 IF(IP2)550,213,550
  213 IF(IP3)600,214,600
  214 IF(IP4)650,215,650
  215 IF(IP5)700,785,700
C
C-----COMPUTE XOMEGA(N), XDOT(N), FOR ACCELRATION INPUT--------
  300 CONTINUE
      GO TO(350,305),IFREQ
  305 CONTINUE
      ECOS1=1.-EX*COSPH
      DFACT3=(1.-FACT2)/OMEGA
      DFACT4=(1.-A2OH*ECOS1-X12*FACT1*RECOH)/OMEGA
```

```
      DFACT5=(-4.*ALPHA(IX)-(2.*(1.-4.*ALPHA2)/OH-2.*ALPHA(IX))*ECOS1+
     1(X12+2.*ALPHA(IX)*(3.-4.*ALPHA2)/OH)*FACT1)*RECOH/(2.*OMEGA)
      DFACT6=(1.-ECOS1)-FACT1*ALPHA(IX)
      DFACT7=FACT1/OMEGA
      DFACT8=(1.-FACT2)*RECOH/OMEGA
      DFACT9=(2.-(1.+4.*ALPHA(IX)*RECOH)*ECOS1-(2.*X12*RECOH-ALPHA(IX))
     1*FACT1)*RECOH/(2.*OMEGA)
      GO TO(308,325),NIN
  308 XOMEGA(1)=OMEGA*X0
      XDOT(1)=XDOTO
      DO 310 I=2,K
      XOMEGA(I)=XOMEGA(I-1)*FACT2+XDOT(I-1)*FACT1-Z(I-1)*DFACT3-S(I-1)
     1*DFACT4-S2ND(I-1)*DFACT5
  310 XDOT(I)=-XOMEGA(I-1)*FACT1+XDOT(I-1)*DFACT6-Z(I-1)*DFACT7
     1       -S(I-1)*DFACT8-S2ND(I-1)*DFACT9
       GO TO 756
  325 CONTINUE
      KRO=KMX+KOOK
      KRA=KMN+KICK
      H2=H**2
      DO 335 I=2,5
      VA=I-1
      TA=VA*.2*H
      COSPT=COS(P*TA)
      SINPT=SIN(P*TA)
      EXT=EXP(-ALPHA(IX)*OMEGA*TA)
      FACTR1=EXT*(COSPT+ALPHA(IX)*SINPT/RADCAL)
      FACTR2=EXT*SINPT/RADCAL
      FACTR3=(1.-FACTR1)/OMEGA
      FACTR4=(TA/H-A2OH*(1.-EXT*COSPT)-X12*FACTR2*RECOH)/OMEGA
      FACTR5=(TA**2/H2-TA/H-(2.*(1.-4.*ALPHA2)*RECOH**2-A2OH)*
     1(1.-EXT*COSPT)+(X12*RECOH+2.*ALPHA(IX)*(3.-4.*ALPHA2)*RECOH**2)
     2*FACTR2)/(2.*OMEGA)
      XMAXO=XOMEGA(KRO)*FACTR1+XDOT(KRO)*FACTR2-Z(KRO)*FACTR3
     1-S(KRO)*FACTR4-S2ND(KRO)*FACTR5
      IF(XMAX-XMAXO    )329,330,330
  329 XMAX=XMAXO
  330 XMINO=XOMEGA(KRA)*FACTR1+XDOT(KRA)*FACTR2-Z(KRA)*FACTR3
     1-S(KRA)*FACTR4-S2ND(KRA)*FACTR5
      IF(XMIN-XMINO    )335,335,332
  332 XMIN=XMINO
  335 CONTINUE
      NIN=1
      GO TO 211
C
C------FREQ1=ZERO FOR FOUNDATION ACCELERATION---------
  350 GO TO(352,365),NIN
  352 XOMEGA(1)=X0
      XDOT(1)=XDOTO
      H2=H**2
      DO 360 I=2,N
      XOMEGA(I)=XOMEGA(I-1)+H*XDOT(I-1)-Z(I-1)*H2/2.-S(I-1)*H2/6.+
     1S2ND(I-1)*H2/24.
  360 XDOT(I)=-Z(I-1)*H-S(I-1)*H/2.+S2ND(I-1)*H/12.
      GC TO 756
  365 CONTINUE
```

```
      NIN=1
      GO TO 211
C
C-------COMPUTE X, XDOT FOR OMEGA=ZERO-----VELOCITY INPUT
  400 GO TO(402,425),NIN
  402 XOMEGA(1)=X0
      XDOT(1)=XDOTO
      DO 410 I=2,N
      XOMEGA(I)=XOMEGA(I-1)+XDOT(I-1)*H-S(I-1)*H*.5+S2ND(I-1)*H/12.
  410 XDOT(I)=XDOT(I-1)-S(I-1)
      GO TO 756
  425 CONTINUE
      NIN=1
      GO TO 211
C
C--------PLOT X VS. T AND XDOT VS. T-------------
  500 GO TO(505,510),IFREQ
  505 DO 506 I=1,N
  506 X(I)=XOMEGA(I)
      GO TO 518
  510 DO 515 I=1,N
  515 X(I)=XOMEGA(I)/OMEGA
  518  XMX=X(1)
       XDMX=XDOT(1)
       XMN=X(1)
       XDMN=XDOT(1)
      DO 530 I=2,N
      IF(X(I)-XMX )521,521,520
  520  XMX=X(I)
  521 IF(X(I)-XMN )522,523,523
  522  XMN=X(I)
  523 IF(XDOT(I)-XDMX )525,525,524
  524  XDMX=XDOT(I)
  525 IF(XDOT(I)-XDMN )526,530,530
  526  XDMN=XDOT(I)
  530 CONTINUE
      DY=(XMX -XMN )/ZN
      CALL GRIDIV(1,T(1),T(N),XMN, XMX, DX,DY,4,4,4,4,6,6)
      CALL APLOTV(N,T,X,1,1,1,42,IER)
      IF(IER)531,532,531
  531 WRITE(6,913) IER,FREQ
  532 NN=N-1
      DO 535 I=1,NN
      CALL LINEV(NXV(T(I)),NYV(X(I)),NXV(T(I+1)),NYV(X(I+1)))
  535 CONTINUE
      CALL PRINTV(-15,15HTIME IN SECONDS,452,6)
      CALL PRINTV(-23,23HFREQ=       CYCLES/SEC.,20,3)
      CALL LABLV(FREQ,60,3,6,1,4)
      CALL PRINTV(-8,8HALPHA=  ,20,17)
      CALL LABLV(ALPHA(IX),72,17,6,1,1)
      CALL APRNTV(0,-14,-11,11HX  RESPONSE,4,600)
      DY=(XDMX -XDMN )/ZN
      CALL GRIDIV(1,T(1),T(N),XDMN, XDMX, DX,DY,4,4,4,4,6,6)
      CALL APLOTV (N,T,XDOT, 1,1,1,42,IERA)
      IF(IERA) 538,539,538
  538 WRITE(6,914) IERA,FREQ
```

```
          SNERD        -  EFN    SOURCE  STATEMENT   -   IFN(S)   -

  539 DO 540 I=1,NN
      CALL LINEV(NXV(T(I)),NYV(XDOT(I)),NXV(T(I+1)),NYV(XDOT(I+1)))
  540 CONTINUE
      CALL PRINTV(-15,15HTIME IN SECONDS,452,6)
      CALL PRINTV(-23,23HFREQ=          CYCLES/SEC.,20,3)
      CALL LABLV(FREQ,60,3,6,1,4)
      CALL PRINTV(-8,8HALPHA=  ,20,17)
      CALL LABLV(ALPHA(IX),72,17,6,1,1)
      CALL APRNTV(0,-14,-22,22HVELOCITY RESPONSE XDOT,4,688)
      GO TO 212
C
C---------PLOT Y(ACCELERATION) VS. TIME-----------
  550 CONTINUE
      GO TO(213,551),IFREQ
  551 CONTINUE
  560 DO 562 I=1,N
  562 X(I)=-XOMEGA(I)*OMEGA
       XMX=X(1)
       XMN=X(1)
      DO 566 I=2,N
      IF(XMX -X(I))563,564,564
  563  XMX=X(I)
  564 IF(XMN -X(I))566,566,565
  565  XMN=X(I)
  566 CONTINUE
      DY=(XMX -XMN )/ZN
      CALL GRIDIV(1,T(1),T(N),XMN, XMX, DX,DY,4,4,4,4,6,6)
      CALL APLOTV(N,T,X,1,1,1,42,IERB)
      IF(IERB)570,571,570
  570 WRITE(6,919) IERB,FREQ
  571 NN=N-1
      DO 575 I=1,NN
      CALL LINEV(NXV(T(I)),NYV(X(I)),NXV(T(I+1)),NYV(X(I+1)))
  575 CONTINUE
      CALL PRINTV(-15,15HTIME IN SECONDS,452,6)
      CALL PRINTV(-23,23HFREQ=          CYCLES/SEC.,20,3)
      CALL LABLV(FREQ,60,3,6,1,4)
      CALL PRINTV(-8,8HALPHA=  ,20,17)
      CALL LABLV(ALPHA(IX),72,17,6,1,1)
      CALL APRNTV(0,-14,-26,26HABSOLUTE OR Y ACCELERATION,4,720)
      GO TO 214
C
C
C--------------FOUR COORDINATE GRID------
  600 CONTINUE
      INI=1+INI
      OSCIL(INI)=FREQ
      VEL(INI)=AMAX1(ABS(XMAX),ABS(XMIN))
      GO TO (601,602),IALPHA
  601 RESID(INI)=SQRT(XOMEGA(KH)**2+XDOT(KH)**2)
      IF(RESID(INI)-.1E-19)604,604,602
  602 IF(FREQ-.1E-19)604,604,603
  603 IF(VEL(INI)-.1E-19)604,604,605
  604 NOFREQ=NOFREQ-1
      INI=INI-1
  605 IF(ABS(FREQ-FREQ2)-.1E-09)606,606,214
```

```
  606 CONTINUE
      CALL SMXYV(1,1)
      FRQSML=OSCIL(1)
      VELSML=VEL(1)
      RESSML=RESID(1)
      DO 616 I=2,NOFREQ
      IF(OSCIL(I)-FRQSML)611,612,612
  611 FRQSML=OSCIL(I)
  612 IF(VEL(I)-VELSML)613,614,614
  613 VELSML=VEL(I)
  614 IF(RESID(I)-RESSML)615,615,616
  615 RESSML=RESID(I)
  616 CONTINUE
      ORDSML=AMIN1(VELSML,RESSML)
C
C-------TO FIND THE LIMITS FOR THE (4X3) CYCLES------------
C
      IF(ALOG10(ORDSML))620,621,621
  620 LOGURD=ALOG10(ORDSML)-1.
      GO TO 622
  621 LOGORD=ALOG10(ORDSML)
  622 IF(ALOG10(FRQSML))623,624,624
  623 LOGFRQ=ALOG10(FRQSML)-1.
      GC TO 625
  624 LOGFRQ=ALOG10(FRQSML)
  625 ORCSML=10.**LOGORD
      ORDLG=ORDSML*10.**4
      FRQSML=10.**LOGFRQ
      FRQLG=FRQSML*10.**3
C-----PLOT LOG-LOG GRID FOR VELOCITY VS FREQUENCY-------
      CALL GRID1V(1,FHQSML,FRQLG,ORDSML,ORDLG,1.0,1.0,1,1,1,1,-2,-2)
C-----TO FIND LARGEST 1X10 TO THE PTH POWER LINE FOR X--------
      OMSTRT=2.*PI*FRQSML
      TEMP=ALOG10(ORDLG/OMSTRT)
      IF(TEMP)627,628,628
  627 LOP=TEMP-1.
      GO TO 629
  628 LOP=TEMP
  629 D1=10.**LOP
      V1=OMSTRT*D1
      WIG=10.*ORDSML
      XMARGN=NXV(FRQLG)-NXV(FRQSML)
      YMARGN=NYV(ORDLG)-NYV(WIG)
      SLOPE=YMARGN/XMARGN
      IXCOR=4+NXV(FRQSML)
      CALL PRINTV(-1,1HD,IXCOR,NYV(V1))
      CALL PRINTV(-2,2HD=,900,17)
      CALL LABLV(D1,924,17,-2,1,3)
C------DRAW LINES UP FROM V1-----------
      VIS=0.
      DO 632 I=1,9
      VIS=VIS+V1
      IF(ORDLG-VIS)647,630,630
  630 XTCH=NYV(ORDLG)-NYV(VIS)
      ITCH=XTCH/SLOPE
      ITCH=NXV(FRQSML)+ITCH
```

```
      KITCH=NYV(ORDLG)
      CALL LINEV (NXV(FRQSML),NYV(VIS),ITCH,KITCH)
  632 CONTINUE
C-------DRAW LINES FROM V1 DOWN----------
  647 DO 638 J=1,20
      LAL=LOP-J
      LAN=LAL+1
      DLAN=10.**LAN
      DLAL=10.**LAL
      DO 638 I=1,9
      EFT1=I
      VIS=OMSTRT*DLAN-OMSTRT*DLAL*EFT1
      IF(VIS-ORDSML)639,633,633
  633 KITCH=NYV(ORDLG)-NYV(VIS)
      IYMARG=YMARGN
      IF(IYMARG-KITCH)635,634,634
  634 ZITCH=KITCH
      ITCH=ZITCH/SLOPE
      GO TO 637
  635 ITCH=XMARGN
      KITCH=YMARGN
  637 ITCH=ITCH+NXV(FRQSML)
      KITCH=KITCH+NYV(VIS)
      CALL LINEV (NXV(FRQSML),NYV(VIS),ITCH,KITCH)
  638 CONTINUE
C------DRAW FROM THE RIGHT ORDINATE THE REMAINING X-LINES------
  639 OMLAST=2.*PI*FRQLG
      LEFT2=J
      LEFT1=EFT1
      DO 641 J=LEFT2,30
      LAL=LOP-J
      LAN=LAL+1
      DLAN=10.**LAN
      DLAL=10.**LAL
      DO 640 I=LEFT1,9
      EFT1=I
      VIS=OMLAST*DLAN-OMLAST*DLAL*EFT1
      IF(VIS-ORDSML)642,636,636
  636 KITCH=NYV(VIS)-NYV(ORDSML)
      CAPT=KITCH
      ITCH=CAPT/SLOPE
      ITCH=NXV(FRQLG)-ITCH
      KITCH=NYV(ORDSML)
      CALL LINEV (NXV(FRQLG),NYV(VIS), ITCH, KITCH)
  640 CONTINUE
      LEFT1=1
  641 CONTINUE
  642 CONTINUE
C---------PLOT POINTS-------
      CALL APLOTV(NOFREQ,OSCIL,VEL,1,1,1,44,LIT)
      IF(LIT)643,644,643
  643 WRITE(6,922) LIT,ALPHA(IX)
  644 GO TO (648,646),IALPHA
  648 CALL APLOTV(NOFREQ,OSCIL,RESID,1,1,1,38,KIT)
      CALL PRINTV(-28,28HOOO =RESIDUAL SHOCK SPECTRUM,NXV(FRQSML),1006)
      IF(KIT)645,646,645
```

```
  645 WRITE(6,923) KIT,ALPHA(IX)
  646 CONTINUE
      CALL PRINTV(-15,15HFREQUENCY (CPS),452,6)
      CALL APRNTV(0,-14,-8,8HVELOCITY,9,576)
      CALL PRINTV(-8,8HALPHA=  ,20,17)
      CALL LABLV(ALPHA(IX),72,17,6,1,1)
      CALL PRINTV(-19,19H*** =SHOCK SPECTRUM,NXV(FRQSML),1015)
C------------GENERATION OF ACCELERATION GRID-------
C-----------TO FIND A1-----------
      TEMP=ALOG10(ORDSML*OMSTRT)
      IF(TEMP)850,851,851
  850 LOP=TEMP
      GO TO 853
  851 LOP=TEMP+1.
  853 A1=10.**LOP
      V1=A1/OMSTRT
      CALL PRINTV(-1,1HA,IXCOR,NYV(V1))
      CALL PRINTV(-2,2HA=,900,4)
      CALL LABLV(A1,924,4,-2,1,3)
C------DRAW LINES DOWN FROM A1-------
      KITCH=NYV(ORDSML)
      DO 856 I=1,9
      EFT1=I-1
      VIS=V1*(1.-.1*EFT1)
      IF(ORDSML-VIS)855,855,857
  855 XTCH=NYV(VIS)-NYV(ORDSML)
      ITCH=XTCH/SLOPE
      ITCH=ITCH+NXV(FRQSML)
      CALL LINEV (NXV(FRQSML),NYV(VIS),ITCH, KITCH)
  856 CONTINUE
C--------DRAW LINES FROM A1 UP-------------
  857 DO 870 J=1,20
      LAN=LOP+J-1
      ALAN=10.**LAN
      DO 870 I=2,10
      EFT1=I
      VIS=ALAN/OMSTRT*EFT1
      IF(VIS-ORDLG)858,858,871
  858 KITCH=NYV(VIS)-NYV(ORDSML)
      IYMARG=YMARGN
      IF(IYMARG-KITCH)862,861,861
  861 ZITCH=KITCH
      ITCH=ZITCH/SLOPE
      KITCH=NYV(ORDSML)
      GO TO 868
  862 ITCH=XMARGN
      KITCH=NYV(VIS)-IYMARG
  868 ITCH=ITCH+NXV(FRQSML)
      CALL LINEV (NXV(FRQSML),NYV(VIS),ITCH, KITCH)
  870 CONTINUE
C--------DRAW FROM THE RIGHT ORDINATE ,REMAINING A-LINES---------
  871 LEFT2=J
      LEFT1=EFT1
      KITCH=NYV(ORDLG)
      DO 875 J=LEFT2,30
      LAN=LOP+J-1
```

```
      ALAN=10.**LAN
      DO 874 I=LEFT1,10
      EFT1=I
      VIS=ALAN/OMLAST*EFT1
      IF(VIS-ORDLG)872,872,876
  872 CAPT=NYV(ORDLG)-NYV(VIS)
      ITCH=CAPT/SLOPE
      ITCH=NXV(FRQLG)-ITCH
      CALL LINEV (NXV(FRQLG),NYV(VIS), ITCH,KITCH)
  874 CONTINUE
      LEFT1=2
  875 CONTINUE
  876 CONTINUE
      GO TO 214
C
C------------SHORT FORM----------
  650 CONTINUE
      IF(ABS(FREQ-FREQ1)-.1E-04)651,651,652
  651 WRITE(8,912) ALPHA(IX)
  652 GO TO(658,655),IALPHA
  655 XOMAX=AMAX1(ABS(XMAX),ABS(XMIN))
      GO TO(668,669),IFREQ
  658 RMAX=SQRT(XOMEGA(KH)**2+XDOT(KH)**2)
      XOMAX=AMAX1(ABS(XMAX),ABS(XMIN),ABS(RMAX))
      GO TO(681,678),IFREQ
  668 WRITE(8,906) FREQ,XOMAX
      GO TO 215
  669 WRITE(8,905) FREQ,XOMAX
      GO TO 215
  678 WRITE(8,907) FREQ,XOMAX,RMAX
      GO TO 215
  681 WRITE(8,908) FREQ,XOMAX,RMAX
      GO TO 215
C
C---------LONG FORM---------
  700 CONTINUE
      IF(ABS(FREQ-FREQ1)-.1E-04)701,701,702
  701 WRITE(6,915) ALPHA(IX)
  702 GO TO(704,705),IALPHA
  704 RMAX=SQRT(XOMEGA(KH)**2+XDOT(KH)**2)
      GO TO(743,742),IFREQ
  705 GO TO(726,727),IFREQ
  726 WRITE(6,916) FREQ,XMAX,XMIN
      GC TO 785
  727 WRITE(6,910) FREQ,XMAX,XMIN
      GO TO 785
  742 WRITE(6,910) FREQ,XMAX,XMIN,RMAX
      GO TO 785
  743 WRITE(6,911) FREQ,XMAX,XMIN,RMAX
      GO TO 785
C
C--------PRELIMINARY CALCULATIONS FOR MIN. AND MAX. RESPONSE----------
  756 GO TO (758,757),IALPHA
  757 NX=N
      GO TO 759
  758 NX=KH
```

```
  759 XMAX=XOMEGA(1)
      KMX=1
      XMIN=XOMEGA(1)
      KMN=1
      DO 760 I=2,NX
      IF(XMAX-XOMEGA(I))761,762,762
  761 XMAX=XOMEGA(I)
      KMX=I
  762 IF(XMIN-XOMEGA(I))760,765,765
  765 XMIN=XOMEGA(I)
      KMN=I
  760 CONTINUE
      IF(KMX-1)771,770,771
  770 KMX=KMX+1
  771 IF(KMX-NX)773,772,773
  772 KMX=KMX-1
  773 IF(KMN-1)775,774,775
  774 KMN=KMN+1
  775 IF(KMN-NX)777,776,777
  776 KMN=KMN-1
  777 CONTINUE
      IF(XDOT(KMX-1)*XDOT(KMX))778,778,779
  778 KCOK=-1
      GC TO 781
  779 KOOK=0
  781 CONTINUE
      IF(XDOT(KMN-1)*XDOT(KMN))783,783,784
  783 KICK=-1
      GO TO 950
  784 KICK=0
  950 NIN=2
      GO TO 207
C
C-------EITHER RESTART WITH NEW FREQ. OR RESTART WITH NEW ALPHA OR STOP
  785 CONTINUE
      IF(ABS(FREQ-FREQ2)-.1E-03)800,755,755
  755 FREQ=FREQ+DELTAF
       GO TO 207
  800 CONTINUE
      GO TO 190
  801 WRITE(6,909)
      CALL FRAMEV
      STOP
C
  900 FORMAT(1H1,49X,22HSHOCK SPECTRUM PROGRAM//50X,21HAPPLIED MATH LAB
     1DTMB,///)
  901 FORMAT(40X,38HFOUNDATION ACCELERATION VS TIME(INPUT)//18X,23HFOUND
     1ATION ACCELERATION,36X,15HTIME IN SECONDS)
  902 FORMAT(42X,35HFOUNDATION VELOCITY VS TIME (INPUT)//20X,19HFOUNDATI
     1ON VELOCITY,35X,15HTIME IN SECONDS)
  903 FORMAT(1X,F35.9, 44X,F20.9)
  904 FORMAT(47H  PLOTTING ERROR NUMBER OF POINTS OUT OF RANGE=,I2//)
  905 FORMAT( 15X,F10.5,29X,F12.7)
  906 FORMAT(10X,11HFIRST FREQ=,F10.5,7X,13HMAX RESPONSE=,F12.7/)
  907 FORMAT( 15X,F10.5,2(29X,F12.7))
  908 FORMAT(10X,11HFIRST FREQ=,F10.5,7X,13HMAX RESPONSE=,F12.7,12X,
```

```
   117HMAX RES RESPONSE=,F12.7)
909 FORMAT(///38X,25HPROGRAM RAN TO COMPLETION)
910 FORMAT(10X,F10.5,3(18X,F12.7))
911 FORMAT(5X,11HFIRST FREQ=,F10.5,9X,9HMAX RESP=,F12.7,10X,9HMIN RESP
   1=,F12.7,7X,15HMAX RESID RESP=,F12.7)
912 FORMAT(1H1,55X,10HSHORT FORM//45X,20HDAMPING COEFFICIENT=,F10.8///
   1/9X,22HFREQUENCY(CYCLES/SEC.),19X,20HMAX RESPONSE X OMEGA,18X,26HM
   2AX RESID RESPONSE X OMEGA)
913 FORMAT(59H  PLOTTING ERROR FOR X VS T, NUMBER OF POINTS OUT OF RAN
   1GE=,I2,6H FREQ=,F10.7//)
914 FORMAT(1X,I2,43H POINTS OUT OF RANGE FOR XDOT VS TIME,FREQ=,F10.7
   1//)
915 FORMAT(1H1,55X,9HLONG FORM//45X,20HDAMPING COEFFICIENT=,F10.8////
   17X,16HFREQ(CYCLES/SEC),12X,20HMAX RESPONSE X OMEGA,10X,20HMIN RESP
   2ONSE X OMEGA,8X,22HMAX RESID RESP X OMEGA)
916 FORMAT(4X,11HFIRST FREQ=,F10.5,10X,9HMAX RESP=,F12.7,10X,9HMIN RES
   1P=,F12.7)
917 FORMAT(1H1,18X,1HI,38X,4HS(I),34X,7HS2ND(I)//
   1(17X,I4,34X,F12.7,28X,F12.7))
918 FORMAT(1H1,50X,19HINTERMEDIATE VALUES/19X,1HI,35X,9HXOMEGA(I),
   131X,7HXDOT(I)//
   2(17X,I3,34X,F12.7,28X,F12.7))
919 FORMAT(1X,I2,43H POINTS OUT OF RANGE FOR Y    VS TIME,FREQ=,F10.7
   1//)
920 FORMAT(3F20.8)
921 FORMAT(6F15.6)
922 FORMAT(1X,I2,49H POINTS OUT OF RANGE FOR VEL VS. FREQ WITH ALPHA=,
   1F10.8)
923 FORMAT(1X,I2,50H POINTS OUT OF RANGE FOR RESIDUAL PLOT WITH ALPHA=
   1,  F10.8)
     END
```

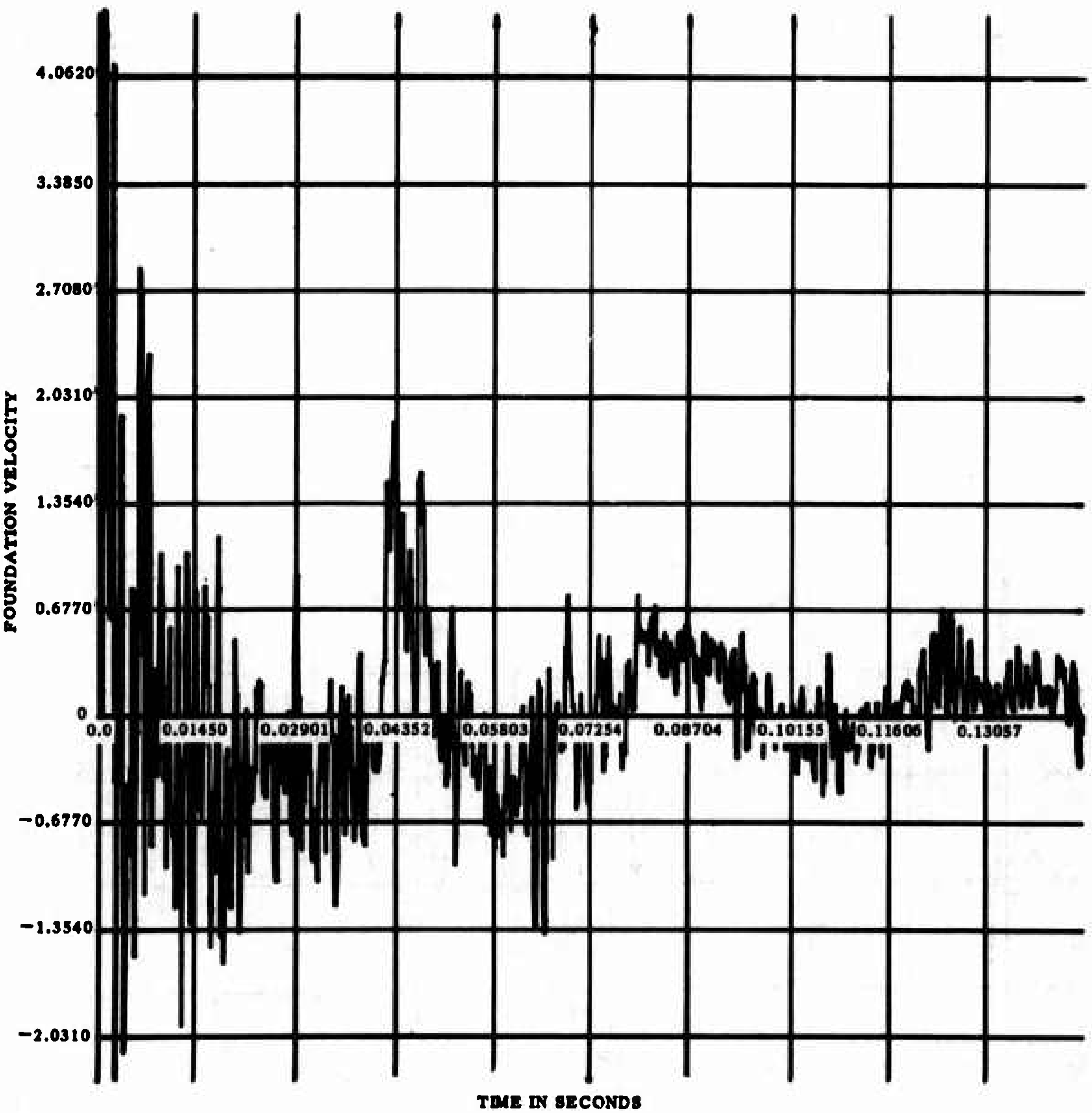


Figure 8 – Input Shock Function (Sample Problem 2)

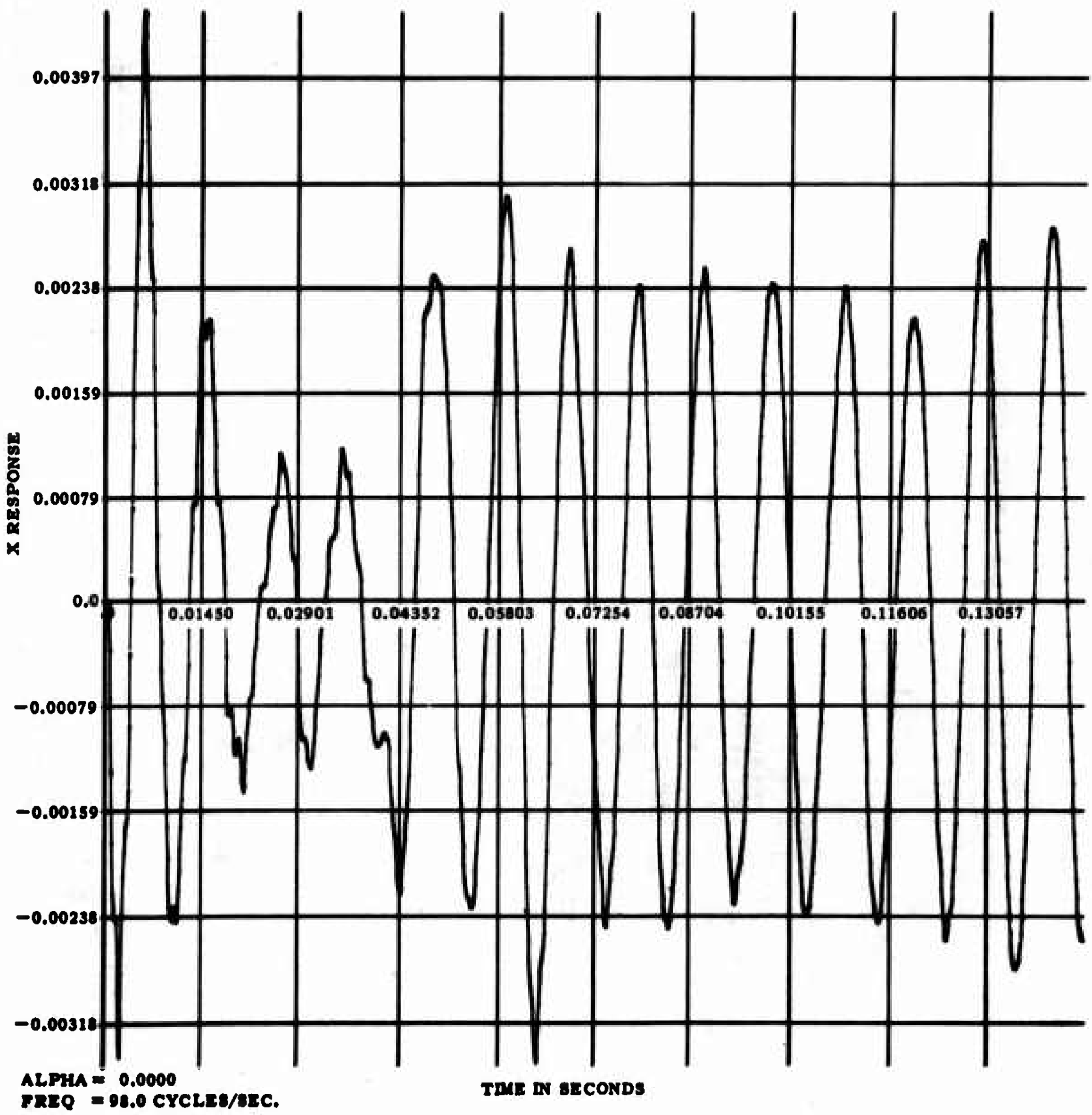


Figure 9 – X versus Time ($IP1$), $\alpha = 0$, $f = 98$ Cycles per Second

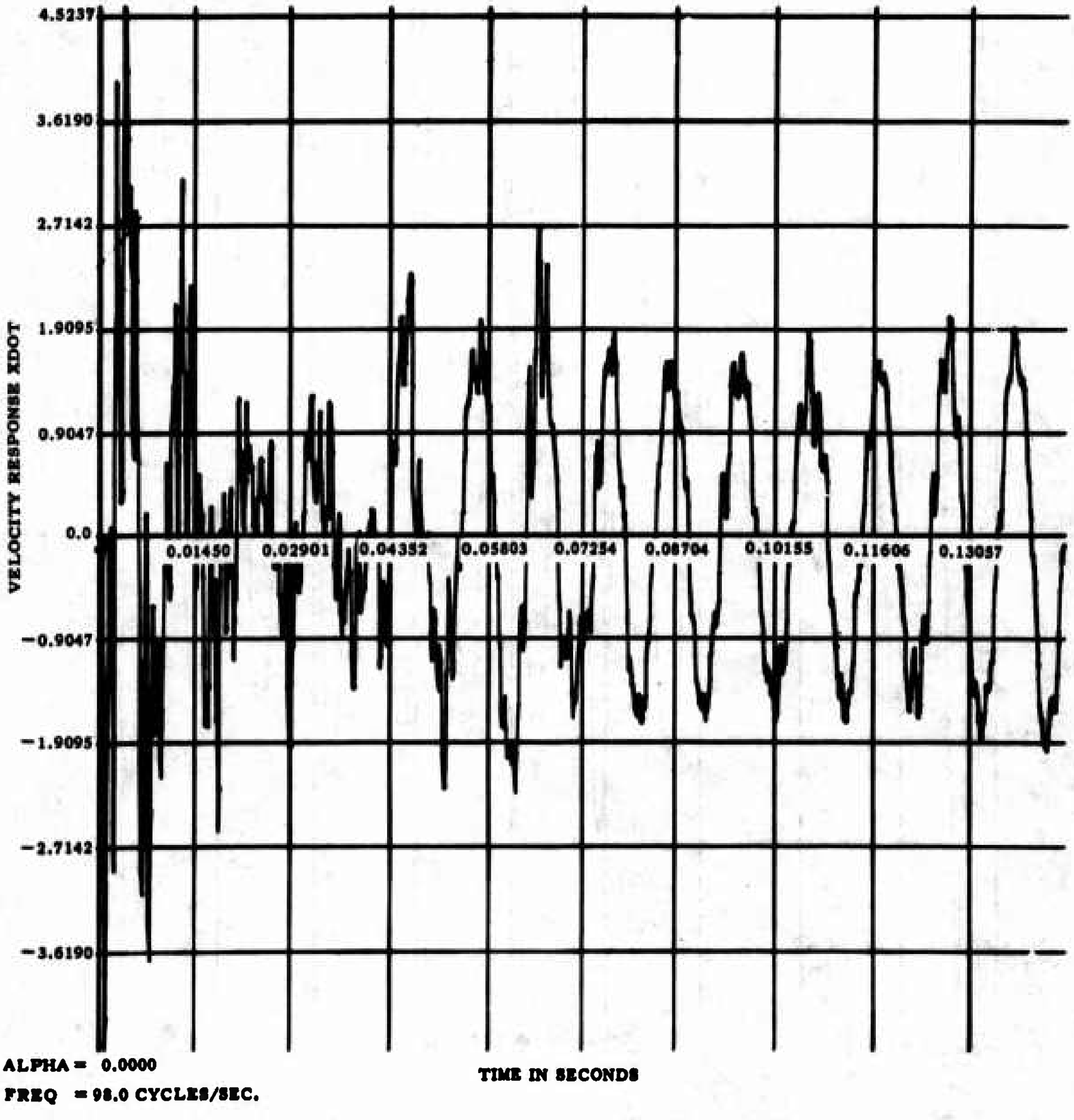


Figure 10 – X versus Time ($IP1$), $\alpha = 0$, $f = 98$ Cycles per Second

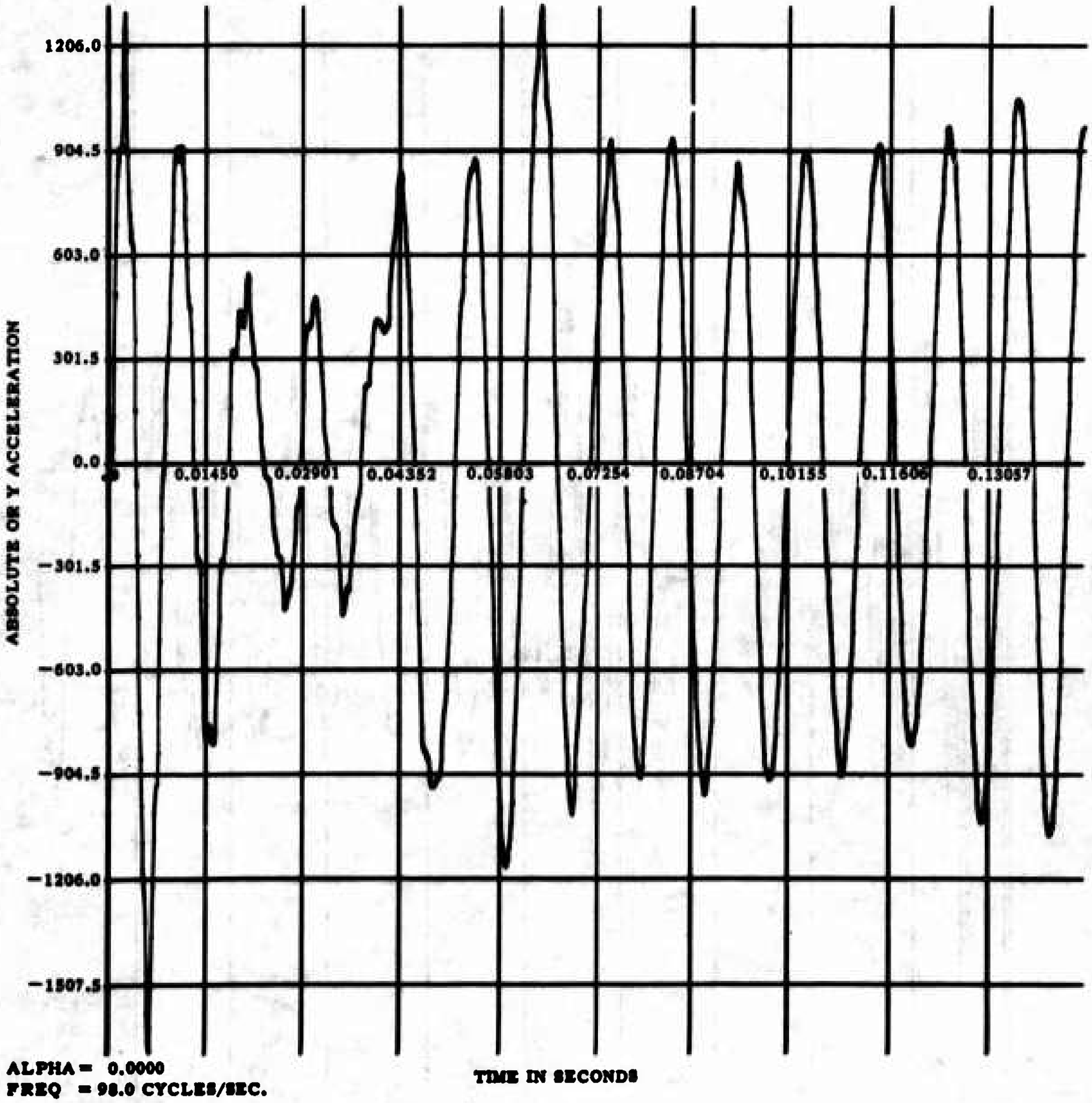


Figure 11 – $-\omega^2 X$ versus Time ($IP2$), $\alpha = 0$, $f = 98$ Cycles per Second

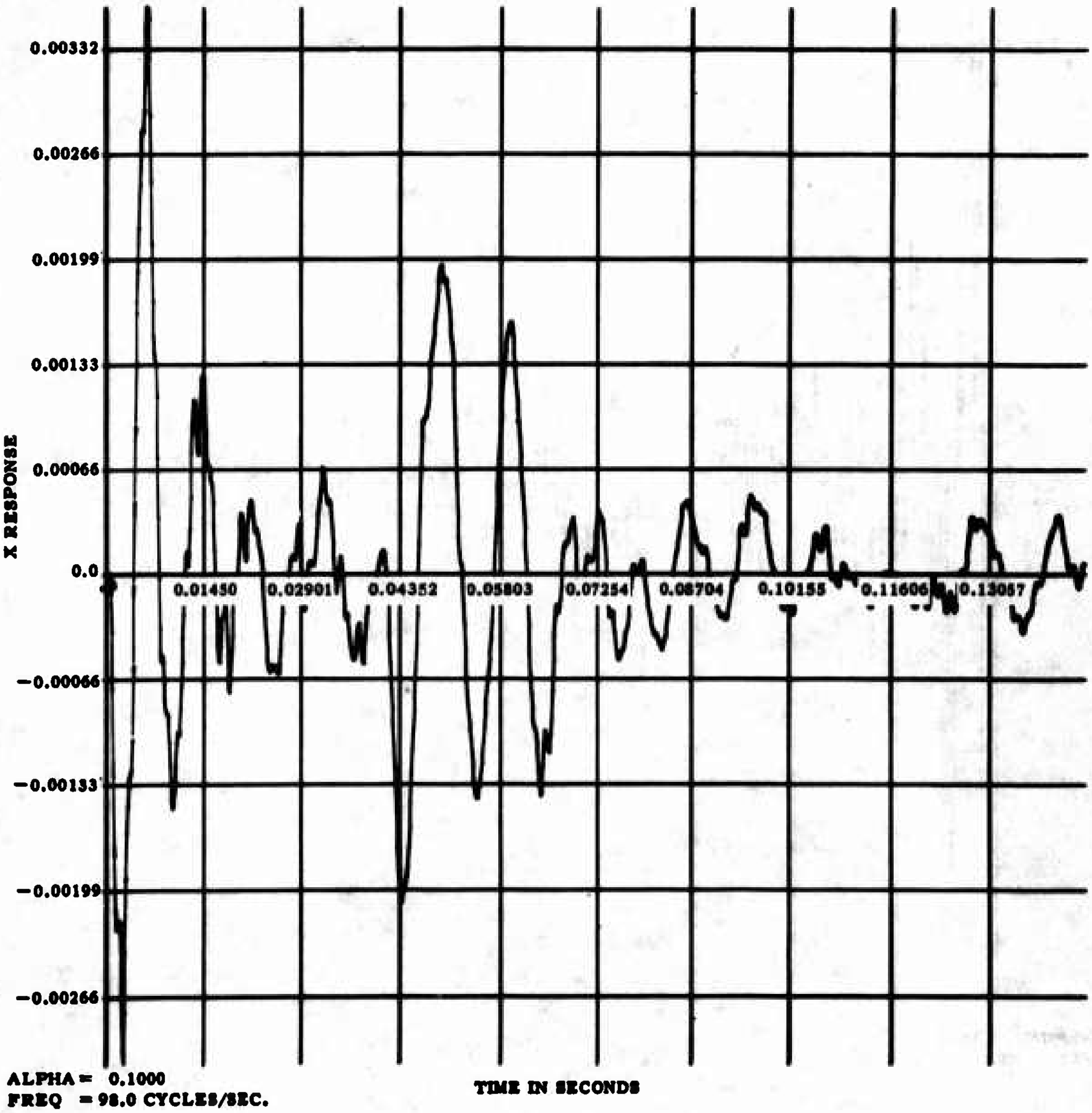


Figure 12 – X versus Time ($IP1$), $\alpha = 0.1$, $f = 98$ Cycles per Second

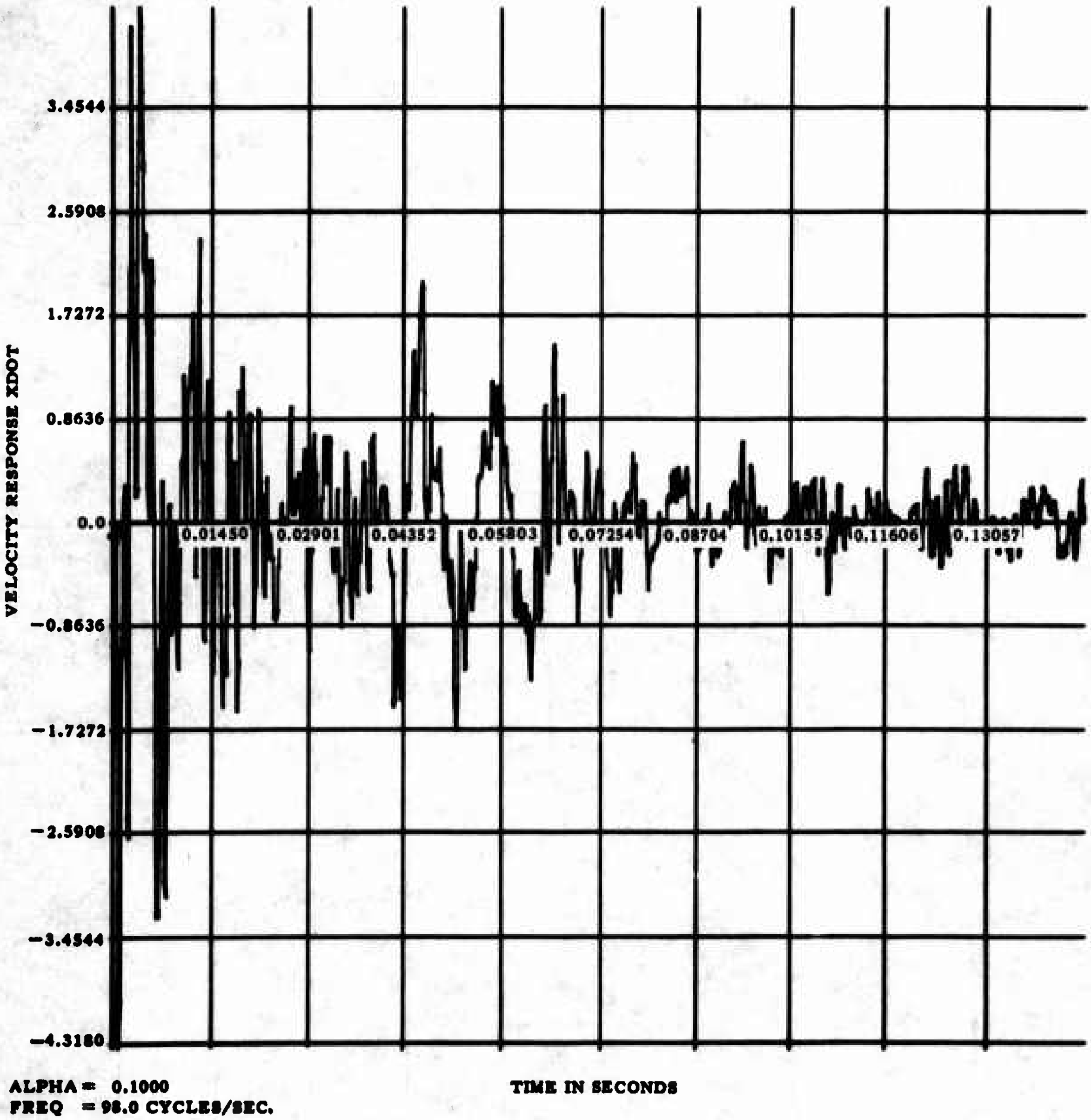


Figure 13 – $\dot{X}$ versus Time ($IP1$), α = 0.1, f = 98 Cycles per Second

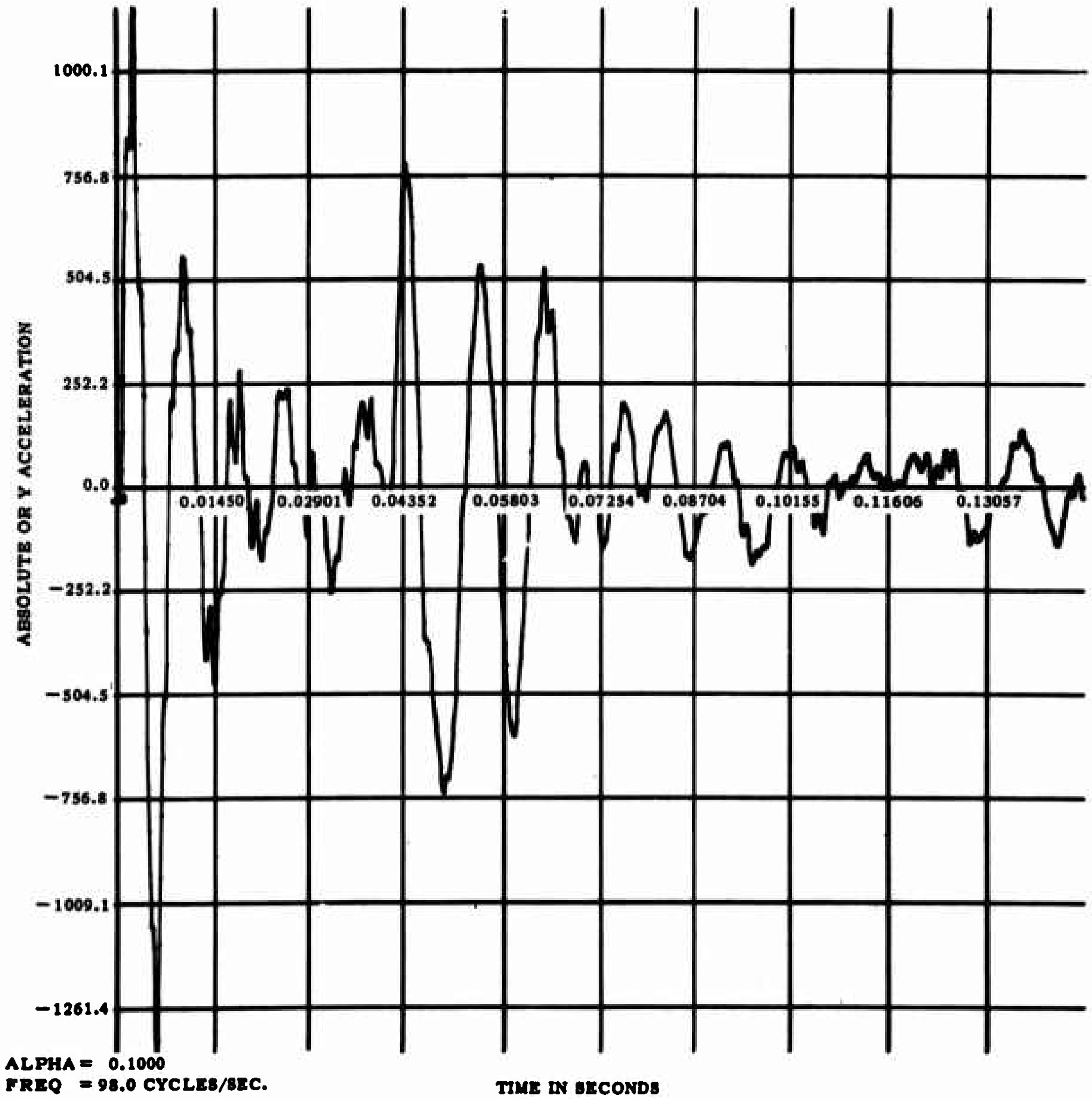


Figure 14 – $-\omega^2 X$ versus Time (*IP*2), $\alpha = 0.1$, $f = 98$ Cycles per Second

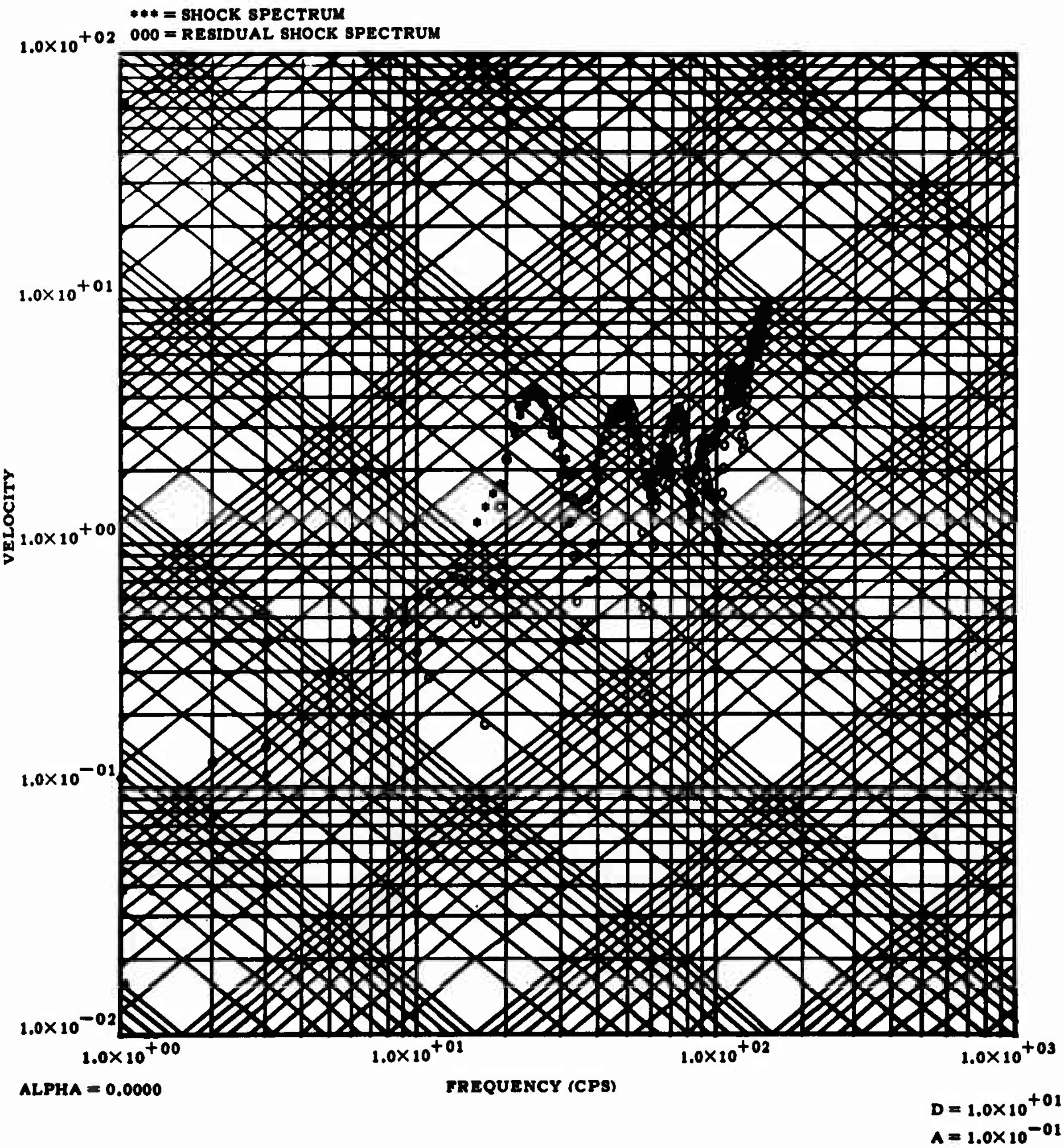


Figure 15 – Four-Coordinate Grid for Sample Problem 2, $\alpha = 0$

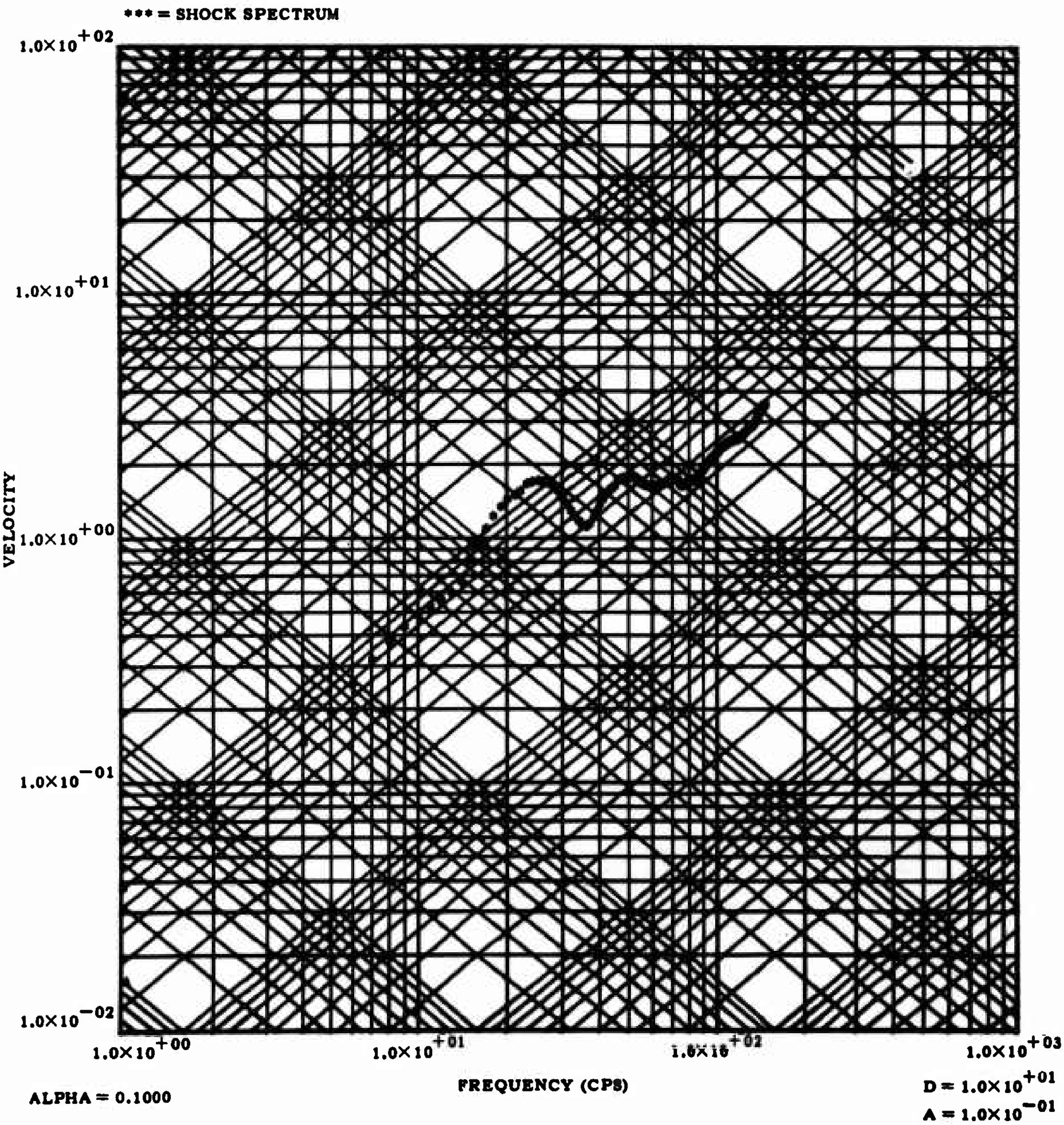


Figure 16 – Four-Coordinate Grid for Sample Problem 2, $\alpha = 0.1$

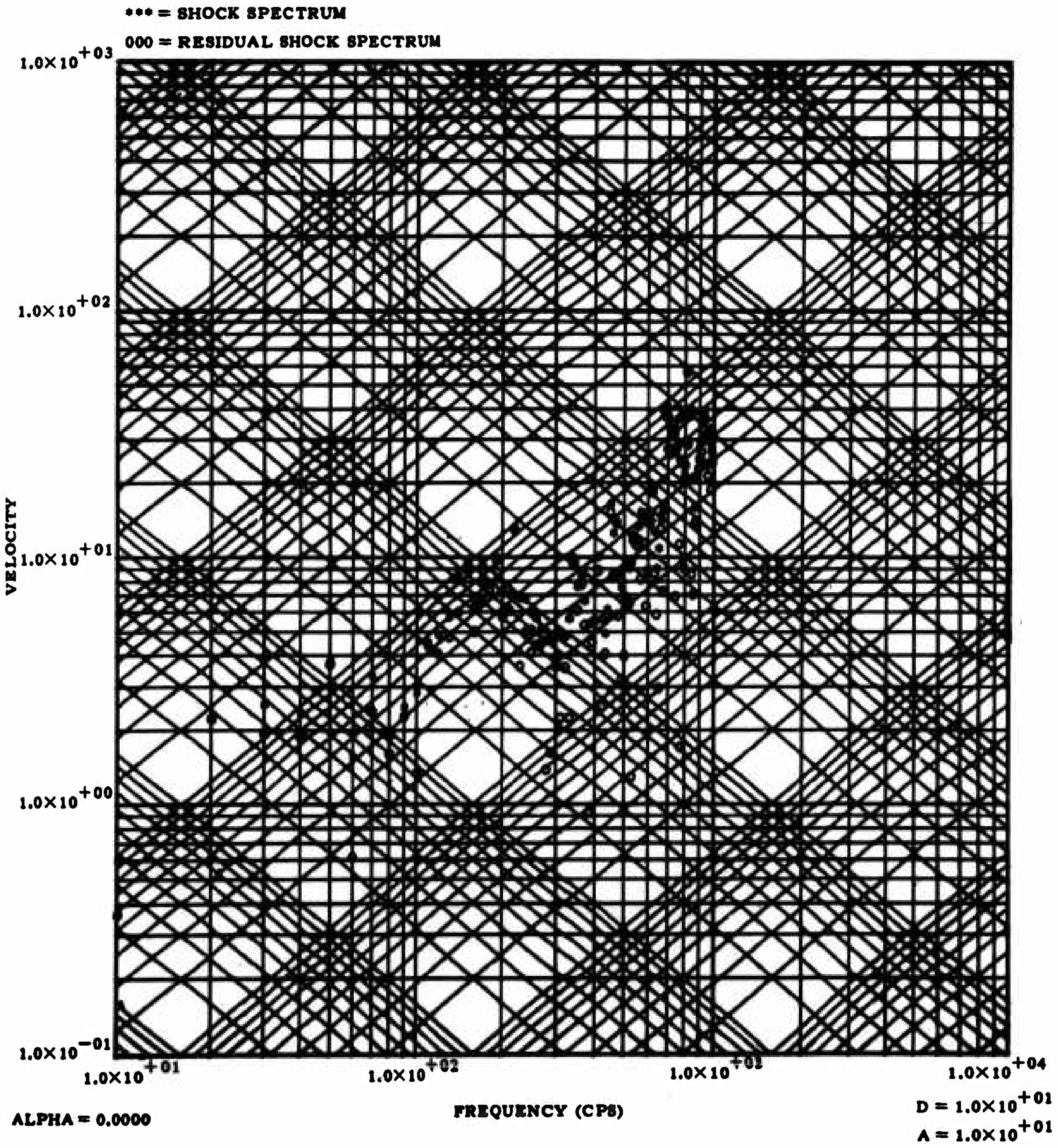


Figure 17 – Four-Coordinate Grid for Sample Problem 2, $\alpha = 0$

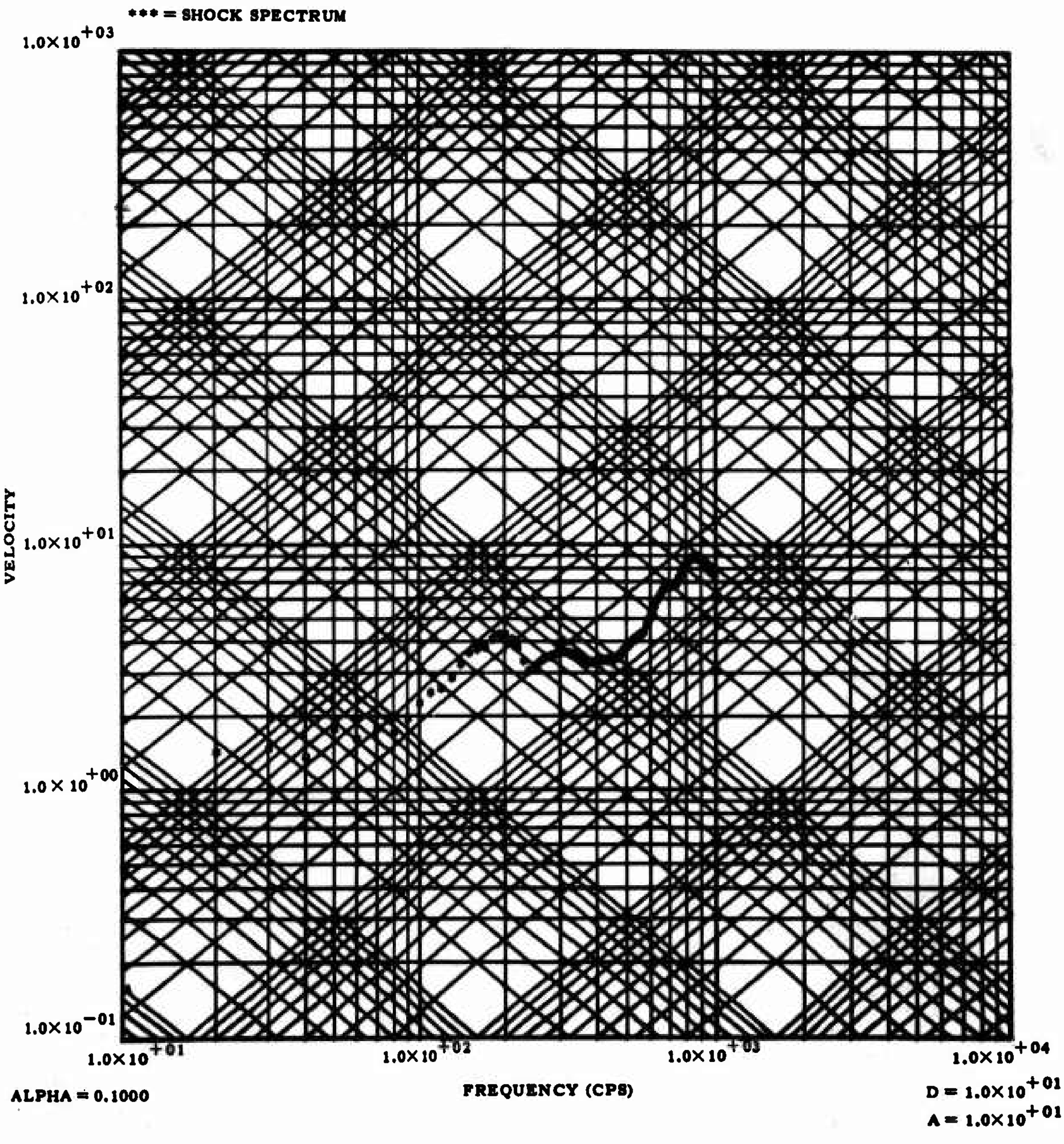


Figure 18 – Four-Coordinate Grid for Sample Problem 2, $\alpha = 0.1$

TABULATION OF SHOCK FUNCTION FOR SAMPLE PROBLEM 2

SHOCK SPECTRUM PROGRAM

APPLIED MATH LAB DTMB

FOUNDATION VELOCITY VS TIME (INPUT)

FOUNDATION VELOCITY	TIME IN SECONDS
-0.	0.
0.069794998	0.000124641
-0.	0.000249282
-0.	0.000373922
0.167507999	0.000498563
1.828628987	0.000623204
1.828628987	0.000747845
4.480838954	0.000872485
4.341248989	0.000997126
4.341248989	0.001121774
1.563407987	0.001246415
1.312145993	0.001371056
0.670031995	0.001495697
0.628154993	0.001620337
0.628154993	0.001744978
1.926341996	0.001869619
3.070979983	0.001994260
3.796847599	0.002118908
4.131863952	0.002243549
-0.418769993	0.002368189
-0.418769993	0.002492830
-2.289275974	0.002617471
-0.963170998	0.002742112
0.321056999	0.002866752
0.628154993	0.002991393
1.423817992	0.003116034
1.870505989	0.003240682
1.912382990	0.003365323
1.912382990	0.003489964
-0.949212000	0.003614604
-1.675079986	0.003739245
-2.121767998	0.003863886
-2.024054974	0.003988527
-1.591325998	0.004113168
-1.046924993	0.004237816
-0.432728998	0.004362456
-0.432728998	0.004487097
-0.879416995	0.004611738
-0.335015997	0.004736379
-0.335015997	0.004861020
0.809621997	0.004985660
0.795662999	0.005110301
0.795662999	0.005234942
-1.521530986	0.005359590
-1.521530986	0.005484231
-1.284227997	0.005608872
-0.097712994	0.005733512
-0.097712994	0.005858153
1.200473994	0.005982794
2.107808977	0.006107435
2.847635984	0.006232075

I	S(I)	S2ND(I)
1	0.0697950	-0.1395900
2	-0.0697950	-0.1395900
3	-0.	0.0697950
4	0.1675080	0.1675080
5	1.6611210	1.4936130
6	0.	-1.6611210
7	2.6522100	2.6522100
8	-0.1395900	-2.7917999
9	0.	0.1395900
10	-2.7778410	-2.7778410
11	-0.2512620	2.5265790
12	-0.6421140	-0.3908520
13	-0.0418770	0.6002370
14	0.	0.0418770
15	1.2981870	1.2981870
16	1.1446380	-0.1535490
17	0.7258680	-0.4187700
18	0.3350160	-0.3908521
19	-4.5506339	-4.8856499
20	-0.	4.5506339
21	-1.8705060	-1.8705060
22	1.3261050	3.1966109
23	1.2842280	-0.0418770
24	0.3070980	-0.9771300
25	0.7956630	0.4885650
26	0.4466880	-0.3489750
27	0.0418770	-0.4048110
28	0.	-0.0418770
29	-2.8615950	-2.8615949
30	-0.7258680	2.1357270
31	-0.4466880	0.2791800
32	0.0977130	0.5444010
33	0.4327290	0.3350160
34	0.5444010	0.1116720
35	0.6141960	0.0697950
36	-0.	-0.6141960
37	-0.4466880	-0.4466880
38	0.5444010	0.9910890
39	-0.	-0.5444010
40	1.1446380	1.1446380
41	-0.0139590	-1.1585970
42	0.	0.0139590
43	-2.3171940	-2.3171940
44	-0.	2.3171940
45	0.2373030	0.2373030
46	1.1865150	0.9492120
47	-0.	-1.1865150
48	1.2981870	1.2981870
49	0.9073350	-0.3908520
50	0.7398270	-0.1675080
51	-0.1395900	-0.8794170
52	0.	0.1395900
53	-1.0190070	-1.0190070
54	-1.2981870	-0.2791800
55	0.	1.2981870
56	-1.5215310	-1.5215310
57	0.9910890	2.5126199

SAMPLE PROBLEM 2

SHORT FORM

DAMPING COEFFICIENT=0.

FREQUENCY(CYCLES/SEC.)	MAX RESPONSE X OMEGA	MAX RESID RESPONSE X OMEGA
FIRST FREQ= 0.	MAX RESPONSE= 0.097889	MAX RES RESPONSE= 0.0978896
1.00000	0.1095097	0.1095097
2.00000	0.1283260	0.1283260
3.00000	0.1480487	0.1480487
4.00000	0.1961872	0.1961872
5.00000	0.2907201	0.2907201
6.00000	0.4043640	0.4043640
7.00000	0.4952695	0.4952695
8.00000	0.5262813	0.5262813
9.00000	0.5555787	0.4768863
10.00000	0.6013559	0.3610662
11.00000	0.6340128	0.2814837
12.00000	0.6896716	0.3965718
13.00000	0.7342171	0.5903094
14.00000	0.8068347	0.7157693
15.00000	1.0185422	0.6914869
16.00000	1.2341474	0.4754660
17.00000	1.4233621	0.1805071
18.00000	1.6244588	0.6661512
19.00000	1.7734649	1.4249891
20.00000	2.2430080	2.2430080
21.00000	3.0149838	3.0149838
22.00000	3.6448261	3.6448261
23.00000	4.0578333	4.0578333
24.00000	4.2135540	4.2135540
25.00000	4.1131192	4.1130483
26.00000	3.9428115	3.7984512
27.00000	3.6078550	3.3436722
28.00000	3.1870430	2.8365744
29.00000	2.8243750	2.3536884
30.00000	2.5459438	1.9341989
31.00000	2.2388102	1.5700569
32.00000	1.8886474	1.2279779
33.00000	1.5540877	0.8888775
34.00000	1.4181810	0.5788067
35.00000	1.4929217	0.4035843
36.00000	1.5354036	0.4823285
37.00000	1.5476327	0.7043338
38.00000	1.6832837	1.0015493
39.00000	2.0291783	1.3891627
40.00000	2.3607207	1.8591387
41.00000	2.7121639	2.3579896
42.00000	3.0728144	2.8092731
43.00000	3.3187485	3.1429442
44.00000	3.5481544	3.3208761
45.00000	3.6153490	3.3554058
46.00000	3.7247854	3.3148841
47.00000	3.8372306	3.3007693
48.00000	3.8723216	3.3856481
49.00000	3.8353378	3.5511247
50.00000	3.8243171	3.6979927
51.00000	3.7124964	3.7124964

52.00000	3.5196299	3.5196299
53.00000	3.1031439	3.1031439
54.00000	2.6821563	2.5038781
55.00000	2.4364013	1.8060076
56.00000	2.1741086	1.1161861
57.00000	1.9244303	0.5432482
58.00000	1.7192324	0.2338138
59.00000	1.5913907	0.3530649
60.00000	1.5615412	0.6132413
61.00000	1.6326082	0.9814259
62.00000	1.8078283	1.4309049
63.00000	2.0372860	1.8665234
64.00000	2.2957990	2.1815353
65.00000	2.5684030	2.2974114
66.00000	2.8104146	2.1942915
67.00000	3.0018617	1.9458009
68.00000	3.1240586	1.7621748
69.00000	3.2147054	1.9134231
70.00000	3.3329537	2.3963684
71.00000	3.3590552	2.9647449
72.00000	3.4136081	3.4136081
73.00000	3.6335309	3.6335309
74.00000	3.5940073	3.5940073
75.00000	3.4375724	3.3297072
76.00000	3.1917780	2.9248355
77.00000	2.9240732	2.4882519
78.00000	2.6814382	2.1137323
79.00000	2.2979606	1.8341253
80.00000	1.8966067	1.6139233
81.00000	1.8983654	1.4123330
82.00000	1.9141865	1.2619478
83.00000	1.9524766	1.2740860
84.00000	2.0125924	1.4955249
85.00000	2.0721104	1.8226829
86.00000	2.1310278	2.1272385
87.00000	2.4492896	2.3329450
88.00000	2.6290929	2.4158924
89.00000	2.7318303	2.3915495
90.00000	2.8147305	2.2963647
91.00000	2.4924067	2.1667942
92.00000	2.5848081	2.0245325
93.00000	2.6845881	1.8785539
94.00000	2.7080944	1.7407992
95.00000	2.6246553	1.6364641
96.00000	2.6741230	1.5888563
97.00000	2.7221211	1.5870130
98.00000	2.7685747	1.5793135
99.00000	2.8137072	1.5071629
100.00000	2.8579095	1.3438914
101.00000	2.9003990	1.1219131
102.00000	2.9411037	0.9559208
103.00000	2.9802526	1.0017868
104.00000	3.0183837	1.2617746
105.00000	3.0545791	1.6234838
106.00000	3.0889529	2.0430281
107.00000	3.1223815	2.5424916
108.00000	3.5392719	3.1401064
109.00000	4.1299683	3.8001768
110.00000	4.5506318	4.4312888

111.00000	4.9180353	4.9180353
112.00000	5.1605774	5.1605774
113.00000	5.1088900	5.1088900
114.00000	5.2221972	4.7902650
115.00000	5.2264419	4.3263391
116.00000	5.1743202	3.9217785
117.00000	5.0552927	3.7702748
118.00000	5.0053889	3.8811407
119.00000	5.0498954	4.0580061
120.00000	4.9054598	4.0795549
121.00000	4.5650097	3.8303832
122.00000	4.4377704	3.3348623
123.00000	4.6227762	2.7690262
124.00000	4.7996786	2.4491791
125.00000	4.9577858	2.6009278
126.00000	5.0841432	3.0533760
127.00000	5.1950735	3.5252700
128.00000	5.3587962	3.9149982
129.00000	5.5079285	4.2901475
130.00000	5.7734312	4.7779626
131.00000	6.1650184	5.4244907
132.00000	6.4919042	6.1341902
133.00000	6.7610561	6.7346961
134.00000	7.0736874	7.0736874
135.00000	7.0824062	7.0824062
136.00000	6.9371608	6.8039070
137.00000	7.3012248	6.3890858
138.00000	7.6481749	6.0453869
139.00000	7.9750189	5.9261927
140.00000	8.3794281	6.0295410
141.00000	8.7737249	6.2378101
142.00000	9.0665296	6.4598599
143.00000	9.1536417	6.7180179
144.00000	8.9859740	7.1149158
145.00000	8.6898987	7.7136006
146.00000	9.0480826	8.4419036
147.00000	9.2947682	9.1180078
148.00000	9.5446296	9.5318438
149.00000	9.5566189	9.5566189
150.00000	9.3128608	9.1567861

SHORT FORM

DAMPING COEFFICIENT=0.09999999

FREQUENCY(CYCLES/SEC.)	MAX RESPONSE X OMEGA	MAX RESID RESPONSE X OMEGA
FIRST FREQ= 0.	MAX RESPONSE= 0.0061198	
1.00000	0.0379408	
2.00000	0.0759543	
3.00000	0.1121684	
4.00000	0.1470673	
5.00000	0.1962810	
6.00000	0.2563012	
7.00000	0.3192773	
8.00000	0.3809440	
9.00000	0.4366131	
10.00000	0.4865843	
11.00000	0.5306858	

12.00000	0.5658847
13.00000	0.6025072
14.00000	0.6711083
15.00000	0.8182884
16.00000	0.9723425
17.00000	1.1059622
18.00000	1.2378344
19.00000	1.3542458
20.00000	1.4517261
21.00000	1.5121502
22.00000	1.5715036
23.00000	1.6811380
24.00000	1.7121034
25.00000	1.7406730
26.00000	1.7244194
27.00000	1.7011797
28.00000	1.6455966
29.00000	1.5659805
30.00000	1.4881206
31.00000	1.3915268
32.00000	1.3046203
33.00000	1.2307312
34.00000	1.1768354
35.00000	1.1412443
36.00000	1.1275853
37.00000	1.1573816
38.00000	1.2238106
39.00000	1.3000138
40.00000	1.3783154
41.00000	1.4517578
42.00000	1.5283500
43.00000	1.5851121
44.00000	1.6185577
45.00000	1.6572430
46.00000	1.7248740
47.00000	1.7714903
48.00000	1.7898907
49.00000	1.7884930
50.00000	1.7805658
51.00000	1.8021202
52.00000	1.8000705
53.00000	1.7781544
54.00000	1.7419721
55.00000	1.7053011
56.00000	1.6871361
57.00000	1.6672338
58.00000	1.6498456
59.00000	1.6380376
60.00000	1.6334237
61.00000	1.6367144
62.00000	1.6470296
63.00000	1.6606574
64.00000	1.6741299
65.00000	1.6838090
66.00000	1.6947559
67.00000	1.7340452
68.00000	1.7647597
69.00000	1.7841267
70.00000	1.7903096

71.00000	1.7822394
72.00000	1.7600802
73.00000	1.7254987
74.00000	1.6804896
75.00000	1.6525075
76.00000	1.6666257
77.00000	1.6804841
78.00000	1.6940802
79.00000	1.7074174
80.00000	1.7204895
81.00000	1.7332981
82.00000	1.7458411
83.00000	1.7581136
84.00000	1.7701208
85.00000	1.7818605
86.00000	1.7970380
87.00000	1.8364982
88.00000	1.8752276
89.00000	1.9133636
90.00000	1.9504764
91.00000	1.9865146
92.00000	2.0214288
93.00000	2.0551688
94.00000	2.0882823
95.00000	2.1203047
96.00000	2.1510450
97.00000	2.1804587
98.00000	2.2090842
99.00000	2.2392856
100.00000	2.2687969
101.00000	2.2970434
102.00000	2.3247267
103.00000	2.3510329
104.00000	2.3759255
105.00000	2.3993689
106.00000	2.4219209
107.00000	2.4433489
108.00000	2.4632638
109.00000	2.4816327
110.00000	2.4984304
111.00000	2.5136293
112.00000	2.5281751
113.00000	2.5411911
114.00000	2.5525643
115.00000	2.5622746
116.00000	2.5703015
117.00000	2.5777414
118.00000	2.5835108
119.00000	2.5875728
120.00000	2.5956801
121.00000	2.6275118
122.00000	2.6583672
123.00000	2.6882212
124.00000	2.7170585
125.00000	2.7448299
126.00000	2.7722445
127.00000	2.7989026
128.00000	2.8244750
129.00000	2.8489405

130.00000	2.8722792
131.00000	2.8952513
132.00000	2.9174094
133.00000	2.9384122
134.00000	2.9582444
135.00000	3.0048671
136.00000	3.0413390
137.00000	3.1156944
138.00000	3.1688772
139.00000	3.2194193
140.00000	3.2685814
141.00000	3.3155413
142.00000	3.3596560
143.00000	3.4028047
144.00000	3.4431707
145.00000	3.4806741
146.00000	3.5170129
147.00000	3.5502561
148.00000	3.5803437
149.00000	3.6075555
150.00000	3.6334579

SHORT FORM

DAMPING COEFFICIENT=0.

FREQUENCY(CYCLES/SEC.)	MAX RESPONSE X OMEGA	MAX RESID RESPONSE X OMEGA
10.00000	0.6013559	0.3610662
20.00000	2.2430080	2.2430080
30.00000	2.5459438	1.9341989
40.00000	2.3607207	1.8591387
50.00000	3.8243171	3.6979927
60.00000	1.5615412	0.6132413
70.00000	3.3329537	2.3963684
80.00000	1.8966067	1.6139233
90.00000	2.5147305	2.2963647
100.00000	2.8579095	1.3438914
110.00000	4.5506318	4.4312588
120.00000	4.9054598	4.0795549
130.00000	5.7734312	4.7779626
140.00000	8.3794281	6.0295410
150.00000	9.3120608	9.1567861
160.00000	6.4903356	5.0191651
170.00000	8.1024095	6.6630763
180.00000	7.8792377	7.3785419
190.00000	10.0076611	9.8079482
200.00000	7.3857204	5.7535270
210.00000	7.1775007	6.1274644
220.00000	13.1304870	13.1304870
230.00000	6.8791582	3.6237543
240.00000	6.7953739	4.9972654
250.00000	5.1381746	4.1500866
260.00000	5.7415234	4.4100481
270.00000	5.1376196	4.4807295
280.00000	4.6604704	1.3837658
290.00000	4.7380349	1.6247082
300.00000	4.7940996	3.6465514
310.00000	4.9940765	2.2577850

4.8112682	3.6082111
5.6847950	2.2581167
9.9516453	9.5493848
7.6642612	6.1251028
8.3929031	7.8221811
6.7073254	5.3521238
5.3967382	0.9335095
5.4726837	4.5590934
7.9915000	5.5663314
10.0929615	8.8656384
5.6722559	2.4948880
4.9223868	4.0816076
6.2064720	5.8942370
16.6626980	15.3588334
12.5990441	8.5707424
14.0287548	14.0240724
8.5671775	5.8224086
7.6053912	3.2154393
7.0414768	4.0217970
6.8870090	6.3562272
9.0612003	6.5626441
9.5879017	1.2931048
12.4685265	11.7681925
11.7912351	11.2566628
13.3713896	11.7661412
15.4383683	8.2025073
14.8852375	11.5208479
14.0197783	6.3820055
14.2594140	8.93[illegible]6409
15.1948453	14.0344567
18.7635851	18.5134978
12.7766875	8.6071843
9.0435599	5.8823307
10.9088503	2.9627771
14.4142867	13.1337078
15.6080470	7.3286763
39.9168267	39.4246798
41.0169787	37.3638587
37.2481532	27.6386724
33.5364890	26.4047632
33.1622615	27.3717346
33.0957823	31.7338808
26.6072156	6.9213288
36.0618491	28.1872778
25.2506065	11.3558303
24.2740149	1.6996583
39.0256066	37.8539357
21.6589115	9.0666267
29.5010610	23.762310[illegible]
57.1597290	57.1374674
37.5797143	28.8460753
40.2439532	37.9155636
20.9892118	8.5253859
21.1313868	7.1144326
21.1676102	13.9601575
21.1024454	16.2059939
20.9411783	13.9906071
25.1282744	23.0315237
29.0582066	25.5303710

910.00000	31.6416688	27.0811985
920.00000	37.9951839	35.8295188
930.00000	38.8813939	37.6841989
940.00000	31.5943122	31.0188282
950.00000	31.3997571	24.0365834
960.00000	29.7507398	21.4417698
970.00000	33.4948893	31.9906242
980.00000	27.3976500	18.8603947
990.00000	26.5197105	24.4738948
1000.00000	23.5731676	23.2734306

SHORT FORM

DAMPING COEFFICIENT=C.09999999

FREQUENCY(CYCLES/SEC.)	MAX RESPONSE X OMEGA	MAX RESID RESPONSE X OMEGA
10.00000	0.4865843	
20.00000	1.4517261	
30.00000	1.4881206	
40.00000	1.3783154	
50.00000	1.7805658	
60.00000	1.6334237	
70.00000	1.7903096	
80.00000	1.7204895	
90.00000	1.9504764	
100.00000	2.2687969	
110.00000	2.4984304	
120.00000	2.5956801	
130.00000	2.8722792	
140.00000	3.2685814	
150.00000	3.6334579	
160.00000	3.7313687	
170.00000	3.8233187	
180.00000	4.1514860	
190.00000	4.3373303	
200.00000	4.3296462	
210.00000	4.1441451	
220.00000	3.8056703	
230.00000	3.3555207	
240.00000	3.0781179	
250.00000	3.2349019	
260.00000	3.3623389	
270.00000	3.4644568	
280.00000	3.5456266	
290.00000	3.6094345	
300.00000	3.6499451	
310.00000	3.6660808	
320.00000	3.6544473	
330.00000	3.6123303	
340.00000	3.5458596	
350.00000	3.4529017	
360.00000	3.3356066	
370.00000	3.2902586	
380.00000	3.3141514	
390.00000	3.3343126	
400.00000	3.3550110	
410.00000	3.3748913	
420.00000	3.3914393	

		320.00000
430.00000	3.4046858	330.00000
440.00000	3.4146634	340.00000
450.00000	3.4214090	350.00000
460.00000	3.4249618	360.00000
470.00000	3.5397916	370.00000
480.00000	3.6127975	380.00000
490.00000	3.7326111	390.00000
500.00000	3.8387387	400.00000
510.00000	3.9468405	410.00000
520.00000	4.0432333	420.00000
530.00000	4.1256196	430.00000
540.00000	4.2130045	440.00000
550.00000	4.2869452	450.00000
560.00000	4.3506643	460.00000
570.00000	4.4250708	470.00000
580.00000	4.7218372	480.00000
590.00000	4.9787236	490.00000
600.00000	5.2252989	500.00000
610.00000	5.4592869	510.00000
620.00000	5.6826928	520.00000
630.00000	5.9193302	530.00000
640.00000	6.1351799	540.00000
650.00000	6.3670688	550.00000
660.00000	6.5542150	560.00000
670.00000	6.7358499	570.00000
680.00000	6.8506564	580.00000
690.00000	6.9155840	590.00000
700.00000	6.9157785	600.00000
710.00000	6.8361212	610.00000
720.00000	6.8793806	620.00000
730.00000	6.8792772	630.00000
740.00000	7.0420097	640.00000
750.00000	7.3435109	650.00000
760.00000	7.6167054	660.00000
770.00000	7.8847350	670.00000
780.00000	8.1104016	680.00000
790.00000	8.3164675	690.00000
800.00000	8.4986007	700.00000
810.00000	8.6319956	710.00000
820.00000	8.7628024	720.00000
830.00000	8.8496922	730.00000
840.00000	8.9005405	740.00000
850.00000	8.9416541	750.00000
860.00000	8.9308807	760.00000
870.00000	8.9139564	770.00000
880.00000	8.8609697	780.00000
890.00000	8.7759501	790.00000
900.00000	8.6821544	800.00000
910.00000	8.5376770	810.00000
920.00000	8.4046476	820.00000
930.00000	8.2147046	830.00000
940.00000	8.1023047	840.00000
950.00000	8.0158021	850.00000
960.00000	7.9092682	860.00000
970.00000	7.7910631	870.00000
980.00000	7.7011219	880.00000
990.00000	7.6215640	890.00000
1000.00000	7.5117384	900.00000

SAMPLE PROBLEM 2

LONG FORM

DAMPING COEFFICIENT=0.

FREQ(CYCLES/SEC)	MAX RESPONSE X OMEGA	MIN RESPONSE X OMEGA	MAX RESID RESP X OMEGA
FIRST FREQ= 0.	MAX RESP= 0.0040351	MIN RESP= -0.0061198	MAX RESID RESP= 0.0978896
1.00000	0.0260267	-0.0384237	0.1095097
2.00000	0.0563091	-0.0765812	0.1283260
3.00000	0.0958435	-0.1144403	0.1480487
4.00000	0.1427370	-0.1515441	0.1961872
5.00000	0.1984845	-0.2222300	0.2907201
6.00000	0.2666554	-0.2530273	0.4043640
7.00000	0.3427713	-0.3190194	0.4952695
8.00000	0.4227995	-0.4498700	0.5262813
9.00000	0.5014756	-0.5555787	0.4768863
10.00000	0.5723159	-0.6013559	0.3610662
11.00000	0.6340128	-0.5619901	0.2814837
12.00000	0.6896716	-0.4292088	0.3965718
13.00000	0.7342171	-0.5929154	0.5903094
14.00000	0.7821219	-0.8068347	0.7157693
15.00000	0.8111091	-1.0185422	0.6914869
16.00000	0.8468281	-1.2341474	0.4754660
17.00000	1.0913280	-1.4233621	0.1805071
18.00000	1.3739737	-1.6244588	0.6661512
19.00000	1.7091911	-1.7734649	1.4249891
20.00000	2.2223526	-2.1979271	2.2430080
21.00000	2.7709621	-2.8311766	3.0149838
22.00000	3.2003321	-3.3648207	3.6448261
23.00000	3.5199502	-3.8185224	4.0578333
24.00000	3.7226839	-4.0739194	4.2135540
25.00000	4.1131192	-4.0671614	4.1130483
26.00000	3.9428115	-3.8646404	3.7984512
27.00000	3.6078550	-3.5441637	3.3436722
28.00000	3.1870430	-3.1640861	2.8365744
29.00000	2.8243750	-2.7722511	2.3536884
30.00000	2.4144118	-2.5459438	1.9341989
31.00000	2.0047871	-2.2388102	1.5700569
32.00000	1.6124741	-1.8886474	1.2279779
33.00000	1.3241983	-1.5540877	0.8888775
34.00000	1.2929534	-1.4151810	0.5788067
35.00000	1.3006522	-1.4929217	0.4035843
36.00000	1.3039326	-1.5384036	0.4823285
37.00000	1.2958518	-1.5476327	0.7043338
38.00000	1.3961354	-1.6532837	1.0015493
39.00000	1.6678373	-2.0291783	1.3891627
40.00000	2.1272458	-2.3607207	1.8591387
41.00000	2.5028031	-2.7121639	2.3579896
42.00000	2.7071109	-3.0728144	2.8092731
43.00000	2.9391128	-3.3187485	3.1429442
44.00000	3.2419096	-3.5481544	3.3208761
45.00000	3.5292770	-3.6153490	3.3554058
46.00000	3.7247554	-3.6995209	3.3148841
47.00000	3.8372306	-3.7997294	3.3007693
48.00000	3.8723216	-3.8218937	3.3856481
49.00000	3.8039968	-3.8353378	3.5511247
50.00000	3.8243171	-3.7214325	3.6979927
51.00000	3.6442487	-3.6335270	3.7124964

52.00000	3.2427883	-3.2654262	3.5196299
53.00000	2.8765668	-2.8322416	3.1031439
54.00000	2.6821563	-2.3874932	2.5038781
55.00000	2.4364013	-2.0698121	1.8060076
56.00000	2.1741086	-1.7467531	1.1161861
57.00000	1.9244303	-1.4666813	0.5432482
58.00000	1.7192324	-1.4674329	0.2338138
59.00000	1.5913907	-1.4886238	0.3530649
60.00000	1.5615412	-1.5096125	0.6132413
61.00000	1.6326082	-1.5303922	0.9814259
62.00000	1.8078283	-1.5504650	1.4309049
63.00000	2.0372860	-1.6746893	1.8665234
64.00000	2.2957990	-1.9176139	2.1815353
65.00000	2.5684030	-2.1184689	2.2974114
66.00000	2.8104146	-2.3320462	2.1942915
67.00000	3.0018617	-2.4915555	1.9458009
68.00000	3.1240585	-2.6166694	1.7621748
69.00000	3.2147054	-2.7495598	1.9134231
70.00000	3.3329537	-2.8895755	2.3963684
71.00000	3.3590552	-3.1033257	2.9647449
72.00000	3.2830480	-3.1726665	3.4136081
73.00000	3.3555246	-3.4545123	3.6335389
74.00000	3.5841680	-3.5003092	3.5940073
75.00000	3.4375724	-3.4138071	3.3297072
76.00000	3.1917758	-3.1471445	2.9248385
77.00000	2.8262543	-2.9240732	2.4882519
78.00000	2.5361170	-2.6814382	2.1137323
79.00000	2.2248138	-2.2979606	1.8341253
80.00000	1.8407114	-1.8966067	1.6139233
81.00000	1.8307806	-1.8983654	1.4123330
82.00000	1.8918451	-1.9141865	1.2619478
83.00000	1.9524766	-1.9297428	1.2740860
84.00000	2.0125924	-1.9458352	1.4955249
85.00000	2.0721104	-1.9600604	1.8226029
86.00000	2.1310278	-2.1123387	2.1272385
87.00000	2.4492896	-2.3889008	2.3329450
88.00000	2.6290929	-2.6092039	2.4158924
89.00000	2.7318303	-2.6617799	2.3918498
90.00000	2.5085307	-2.5147308	2.2963647
91.00000	2.4924067	-2.4901567	2.1667942
92.00000	2.5810772	-2.5848881	2.0245325
93.00000	2.6247853	-2.6845801	1.8785539
94.00000	2.6656180	-2.7080944	1.7407992
95.00000	2.6246553	-2.5995757	1.6364641
96.00000	2.6741230	-2.4668835	1.5888563
97.00000	2.7221211	-2.3612758	1.5870130
98.00000	2.7685747	-2.1424510	1.5793138
99.00000	2.8137072	-2.1412351	1.5071629
100.00000	2.8579095	-2.1520202	1.3438914
101.00000	2.9003990	-2.1625885	1.1219131
102.00000	2.9411037	-2.1726985	0.9559208
103.00000	2.9802626	-2.1826203	1.0017868
104.00000	3.0183837	-2.1926143	1.2617746
105.00000	3.0545791	-2.2023187	1.6234038
106.00000	3.0889829	-2.6479473	2.0430251
107.00000	3.1223815	-3.1147088	2.5424916
108.00000	3.5392719	-3.5305354	3.1481064
109.00000	4.1299683	-4.0075887	3.8001760
110.00000	4.5506318	-4.5435206	4.4312588

111.00000	4.8124017	-4.8370142	4.9180353
112.00000	5.0143716	-4.9863667	5.1605774
113.00000	5.0349729	-4.9931408	5.1088900
114.00000	4.8425894	-5.2221972	4.7902650
115.00000	5.0572182	-5.2264419	4.3263391
116.00000	5.1743202	-5.0598040	3.9217785
117.00000	5.0552927	-4.8921168	3.7702748
118.00000	5.0053889	-4.7221187	3.8811407
119.00000	5.0498954	-4.4284284	4.0580061
120.00000	4.9054598	-4.0870823	4.0795549
121.00000	4.5650097	-4.2516337	3.8303832
122.00000	4.4016733	-4.4377704	3.3348623
123.00000	4.6124583	-4.6227762	2.7690262
124.00000	4.7682334	-4.7996786	2.4491791
125.00000	4.8772433	-4.9577858	2.6009278
126.00000	5.0020366	-5.0841432	3.0533760
127.00000	5.1803685	-5.1950735	3.5252700
128.00000	5.3587962	-5.2777988	3.9149982
129.00000	5.5079285	-5.3346325	4.2901475
130.00000	5.7734312	-5.6118770	4.7779626
131.00000	6.1650184	-6.1403028	5.4244907
132.00000	6.3412778	-6.4919042	6.1341902
133.00000	6.7054250	-6.7610561	6.7346961
134.00000	6.8492215	-6.9613044	7.0736874
135.00000	7.0006986	-6.9803497	7.0824062
136.00000	6.9371608	-6.9201233	6.8039070
137.00000	7.1246003	-7.3012248	6.3890858
138.00000	7.5329992	-7.6481749	6.0453869
139.00000	7.9478620	-7.9750189	5.9261927
140.00000	8.3794281	-8.2769624	6.0295410
141.00000	8.7737249	-8.3973836	6.2378101
142.00000	9.0665296	-8.3927698	6.4598599
143.00000	9.1536417	-8.2748826	6.7180179
144.00000	8.9859740	-8.2579801	7.1149158
145.00000	8.6898987	-8.6728413	7.7136006
146.00000	9.0480826	-9.0028075	8.4419036
147.00000	9.2123531	-9.2947682	9.1150078
148.00000	9.5446296	-9.4108183	9.5318438
149.00000	9.5344342	-9.5100416	9.5566189
150.00000	9.2287583	-9.3128608	9.1567861

SAMPLE PROBLEM 2

LONG FORM

DAMPING COEFFICIENT=0.09999999

FREQ(CYCLES/SEC)	MAX RESPONSE X OMEGA	MIN RESPONSE X OMEGA	MAX RESID RESP X OMEGA
FIRST FREQ= 0.	MAX RESP= 0.0040351	MIN RESP= -0.0061198	
1.00000	0.0271717	-0.0379408	
2.00000	0.0577969	-0.0759543	
3.00000	0.0959844	-0.1121684	
4.00000	0.1422809	-0.1470673	
5.00000	0.1962810	-0.1807973	
6.00000	0.2563012	-0.2130117	
7.00000	0.3192773	-0.2800073	
8.00000	0.3809440	-0.3695401	
9.00000	0.4366131	-0.4343356	
10.00000	0.4865843	-0.4529236	
11.00000	0.5306858	-0.4218341	
12.00000	0.5658847	-0.3830994	
13.00000	0.6025072	-0.5247811	
14.00000	0.6251661	-0.6711083	
15.00000	0.6480988	-0.8182884	
16.00000	0.6892952	-0.9723425	
17.00000	0.7266459	-1.1059622	
18.00000	0.8822626	-1.2378344	
19.00000	1.0401853	-1.3542458	
20.00000	1.2497623	-1.4517261	
21.00000	1.4257137	-1.5121502	
22.00000	1.5715036	-1.5457764	
23.00000	1.6811380	-1.6475601	
24.00000	1.7086853	-1.7121034	
25.00000	1.7240752	-1.7406730	
26.00000	1.7143938	-1.7244194	
27.00000	1.7011797	-1.6394011	
28.00000	1.6455966	-1.5325239	
29.00000	1.5659805	-1.4993467	
30.00000	1.4881206	-1.4504690	
31.00000	1.3915268	-1.3873041	
32.00000	1.2918945	-1.3046203	
33.00000	1.2035173	-1.2307312	
34.00000	1.1395501	-1.1768354	
35.00000	1.1086662	-1.1412443	
36.00000	1.1140342	-1.1275853	
37.00000	1.1530259	-1.1573816	
38.00000	1.2179627	-1.2238106	
39.00000	1.2976037	-1.3000138	
40.00000	1.3783154	-1.3720378	
41.00000	1.4517578	-1.4453105	
42.00000	1.5241575	-1.5283500	
43.00000	1.5851121	-1.5747020	
44.00000	1.6185577	-1.5797869	
45.00000	1.6572430	-1.5483766	
46.00000	1.7248740	-1.5363979	
47.00000	1.7714903	-1.5747972	
48.00000	1.7898907	-1.5887947	
49.00000	1.7884930	-1.5943269	
50.00000	1.7805658	-1.5952718	
51.00000	1.8021202	-1.5794198	

52.00000	1.8000705	-1.5494130
53.00000	1.7781544	-1.5084833
54.00000	1.7419721	-1.4611478
55.00000	1.7053011	-1.4125821
56.00000	1.6871361	-1.3673191
57.00000	1.6672335	-1.3556843
58.00000	1.6498456	-1.3742178
59.00000	1.6380376	-1.3925117
60.00000	1.6334237	-1.4105702
61.00000	1.6367144	-1.4284043
62.00000	1.6470296	-1.4460059
63.00000	1.6606574	-1.4633619
64.00000	1.6741299	-1.4804867
65.00000	1.6838090	-1.4973549
66.00000	1.6947559	-1.5139951
67.00000	1.7340452	-1.5303884
68.00000	1.7647597	-1.5465257
69.00000	1.7841267	-1.5624309
70.00000	1.7903096	-1.5780757
71.00000	1.7822394	-1.5934688
72.00000	1.7600802	-1.6086157
73.00000	1.7254987	-1.6234981
74.00000	1.6804896	-1.6381316
75.00000	1.6279886	-1.6525075
76.00000	1.5712712	-1.6666257
77.00000	1.5139166	-1.6804841
78.00000	1.4592212	-1.6940802
79.00000	1.4991477	-1.7074174
80.00000	1.5434386	-1.7204895
81.00000	1.5874270	-1.7332981
82.00000	1.6308033	-1.7458411
83.00000	1.6735087	-1.7581136
84.00000	1.7154078	-1.7701208
85.00000	1.7566825	-1.7818605
86.00000	1.7970380	-1.7933264
87.00000	1.8364982	-1.8045235
88.00000	1.8752276	-1.8154505
89.00000	1.9133636	-1.8261028
90.00000	1.9504764	-1.8364835
91.00000	1.9865146	-1.8466720
92.00000	2.0214288	-1.8568295
93.00000	2.0551688	-1.8667220
94.00000	2.0882823	-1.8763441
95.00000	2.1203047	-1.8856975
96.00000	2.1510450	-1.8947840
97.00000	2.1804587	-1.9035950
98.00000	2.2090842	-1.9121373
99.00000	2.2392856	-1.9204102
100.00000	2.2687969	-1.9284080
101.00000	2.2970434	-1.9361360
102.00000	2.3247267	-1.9435874
103.00000	2.3510329	-1.9507698
104.00000	2.3759255	-1.9576747
105.00000	2.3993689	-1.9643084
106.00000	2.4219209	-1.9706668
107.00000	2.4433489	-1.9767530
108.00000	2.4632638	-1.9825623
109.00000	2.4816327	-1.9880978
110.00000	2.4984304	-1.9933575

111.00000	2.5136293	-1.9983436
112.00000	2.5281751	-2.0030557
113.00000	2.5411911	-2.0074919
114.00000	2.5525643	-2.0116535
115.00000	2.5622746	-2.0155394
116.00000	2.5703015	-2.0191509
117.00000	2.5777414	-2.0224874
118.00000	2.5835108	-2.0255508
119.00000	2.5875728	-2.0283419
120.00000	2.5956801	-2.0308568
121.00000	2.6275118	-2.0549282
122.00000	2.6583672	-2.1308325
123.00000	2.6882212	-2.2056735
124.00000	2.7170505	-2.2793104
125.00000	2.7448299	-2.3523175
126.00000	2.7722445	-2.4243357
127.00000	2.7989026	-2.4948165
128.00000	2.8244750	-2.5636270
129.00000	2.8489405	-2.6315377
130.00000	2.8722792	-2.6980584
131.00000	2.8952513	-2.7626036
132.00000	2.9174094	-2.8253742
133.00000	2.9384122	-2.8871990
134.00000	2.9582444	-2.9467676
135.00000	2.9776415	-3.0048671
136.00000	2.9962702	-3.0613390
137.00000	3.0147992	-3.1156944
138.00000	3.0336479	-3.1688772
139.00000	3.0523041	-3.2194193
140.00000	3.0707277	-3.2685814
141.00000	3.0882752	-3.3155413
142.00000	3.1057992	-3.3596568
143.00000	3.1222547	-3.4028847
144.00000	3.1375520	-3.4431707
145.00000	3.1522428	-3.4806741
146.00000	3.1664564	-3.5170129
147.00000	3.1795024	-3.5502561
148.00000	3.1913715	-3.5803437
149.00000	3.2021606	-3.6075555
150.00000	3.2129558	-3.6334579

SAMPLE PROBLEM 2

LONG FORM

DAMPING COEFFICIENT=0.

FREQ(CYCLES/SEC)	MAX RESPONSE X OMEGA	MIN RESPONSE X OMEGA	MAX RESID RESP X OMEGA
10.00000	0.5723159	-0.6013559	0.3610662
20.00000	2.2223526	-2.1979271	2.2430080
30.00000	2.4144118	-2.5459438	1.9341989
40.00000	2.1272458	-2.3607207	1.8591387
50.00000	3.8243171	-3.7214325	3.6979927
60.00000	1.5615412	-1.5096125	0.6132413
70.00000	3.3329537	-2.8895755	2.3963684
80.00000	1.8407114	-1.8966067	1.6139233
90.00000	2.5085307	-2.5147305	2.2963647
100.00000	2.8579095	-2.1520202	1.3438914
110.00000	4.5506318	-4.5435206	4.4312588
120.00000	4.9054598	-4.0870823	4.0795549
130.00000	5.7734312	-5.6118770	4.7779626
140.00000	8.3794281	-8.2769624	6.0295410
150.00000	9.2287583	-9.3128608	9.1567861
160.00000	6.2057672	-6.4903356	5.0191651
170.00000	8.0960882	-8.1024095	6.6630763
180.00000	7.6781775	-7.8792377	7.3785419
190.00000	9.9505621	-10.0076611	9.8079482
200.00000	7.3857204	-6.9496645	5.7535270
210.00000	7.1457288	-7.1775007	6.1274644
220.00000	12.9272692	-12.9527640	13.1304870
230.00000	6.8791582	-6.7840646	3.6237543
240.00000	6.7953739	-6.6346997	4.9972654
250.00000	4.9254916	-5.1351746	4.1500866
260.00000	5.7415234	-5.7264840	4.4100481
270.00000	5.0764150	-5.1376196	4.4807295
280.00000	4.6604704	-3.8497578	1.3837658
290.00000	4.7380349	-3.2965684	1.6247082
300.00000	4.7940996	-4.3683889	3.6465514
310.00000	4.9940765	-4.8510790	2.2577850
320.00000	4.8112682	-3.8654755	3.6082111
330.00000	5.6847950	-5.0035365	2.2581167
340.00000	9.9463187	-9.9516453	9.5493848
350.00000	7.2514316	-7.6642612	6.1251028
360.00000	8.3929031	-8.3685973	7.8221811
370.00000	6.7073254	-6.6875647	5.3521238
380.00000	5.3967382	-4.7879370	0.9335095
390.00000	5.4726837	-5.0005182	4.5593934
400.00000	7.3466106	-7.9918000	5.5663314
410.00000	9.8315334	-10.0929615	8.0656384
420.00000	5.6722559	-5.6121054	2.4948880
430.00000	4.9223868	-4.9163595	4.0816076
440.00000	6.2064720	-6.0059853	5.8942370
450.00000	16.6626980	-16.4112132	15.3588334
460.00000	12.0812262	-12.5990441	8.5707424
470.00000	14.0287548	-13.8333476	14.0240724
480.00000	8.3241466	-8.5671775	5.8224086
490.00000	7.6053912	-6.9601313	3.2154393
500.00000	6.9682094	-7.0414768	4.0217973
510.00000	6.8845709	-6.8870090	6.3562272
520.00000	9.0612003	-9.0344149	6.5626441

530.00000	9.5879017	-9.4926915	1.2931048
540.00000	12.2454479	-12.4685265	11.7681925
550.00000	11.7912351	-11.7773448	11.2566628
560.00000	13.3713596	-13.1187963	11.7661412
570.00000	15.4383653	-15.3078662	8.2025073
580.00000	14.8800256	-14.8852375	11.5208479
590.00000	13.9738284	-14.0197783	6.3820755
600.00000	13.5483565	-14.2594140	8.9306409
610.00000	15.1948453	-14.9864192	14.0344567
620.00000	18.7635851	-18.4727407	18.5134978
630.00000	12.7766875	-12.6451108	8.6071843
640.00000	9.0435599	-8.9427893	5.8823307
650.00000	10.9088503	-10.6812426	2.9627771
660.00000	14.4142867	-14.3406677	13.1337078
670.00000	15.4063463	-15.6080470	7.3286763
680.00000	39.9168267	-39.8359294	39.4246798
690.00000	40.9539375	-41.0169787	37.3638587
700.00000	37.1573563	-37.2481532	27.6386724
710.00000	33.5364890	-33.5256643	26.4047632
720.00000	32.9295487	-33.1622615	27.3717346
730.00000	33.0957823	-32.8447542	31.7338808
740.00000	25.9581409	-26.6072156	6.9213288
750.00000	35.8290706	-36.0618491	28.1872778
760.00000	25.2506065	-25.0946736	11.3558303
770.00000	24.0413258	-24.2740149	1.6996583
780.00000	39.0256066	-39.0116711	37.8539357
790.00000	21.5589115	-21.4433659	9. 666267
800.00000	29.3503990	-29.5010610	23.7623100
810.00000	57.1597290	-56.9387345	57.1374674
820.00000	37.5797143	-37.2578034	28.8460753
830.00000	39.7792566	-40.2439532	37.9155636
840.00000	19.8272703	-20.9892118	8.5253859
850.00000	19.7017763	-21.1313868	7.1144326
860.00000	20.4062905	-21.1676102	13.9601575
870.00000	20.5703180	-21.1024454	16.2059939
880.00000	20.5931189	-20.9411783	13.9906071
890.00000	25.0197773	-25.1282744	23.0315237
900.00000	28.5140569	-29.0582066	25.5303716
910.00000	31.3670921	-31.6416688	27.0811985
920.00000	37.6792321	-37.9951839	35.8295188
930.00000	38.8544083	-38.8813939	37.6841989
940.00000	31.5943122	-31.3670361	31.0188282
950.00000	31.3997571	-31.2705140	24.0365834
960.00000	29.7507398	-28.8960285	21.4417698
970.00000	33.2809253	-33.4948893	31.9906242
980.00000	27.3976500	-27.0518916	18.8603947
990.00000	26.5197105	-26.1039162	24.4738948
1000.00000	23.5656412	-23.5731676	23.2734306

SAMPLE PROBLEM 2

LONG FORM

DAMPING COEFFICIENT=0.09999999

FREQ(CYCLES/SEC)	MAX RESPONSE X OMEGA	MIN RESPONSE X OMEGA	MAX RESID RESP X OMEGA
10.00000	0.4865843	-0.4529236	
20.00000	1.2497623	-1.4517261	
30.00000	1.4881206	-1.4504690	
40.00000	1.3783154	-1.3720375	
50.00000	1.7905658	-1.5952718	
60.00000	1.6334237	-1.4105702	
70.00000	1.7903096	-1.5780757	
80.00000	1.5434386	-1.7204895	
90.00000	1.9504764	-1.8364835	
100.00000	2.2687969	-1.9284080	
110.00000	2.4984304	-1.9933575	
120.00000	2.5956801	-2.0308568	
130.00000	2.8722792	-2.6980584	
140.00000	3.0707277	-3.2685814	
150.00000	3.2129558	-3.6334579	
160.00000	3.2914393	-3.7313687	
170.00000	3.3894143	-3.8233187	
180.00000	3.4477171	-4.1514869	
190.00000	3.8501138	-4.3373303	
200.00000	4.0007235	-4.3296462	
210.00000	3.8944754	-4.1441451	
220.00000	3.6192376	-3.8056703	
230.00000	3.2816635	-3.3555207	
240.00000	3.0781179	-2.8390148	
250.00000	3.2349019	-2.7411548	
260.00000	3.3623389	-2.8070703	
270.00000	3.4644568	-2.8689104	
280.00000	3.5456266	-2.9266418	
290.00000	3.6094345	-2.9802380	
300.00000	3.6499451	-3.0296787	
310.00000	3.6663808	-3.0749504	
320.00000	3.6544473	-3.1169452	
330.00000	3.6123303	-3.1569805	
340.00000	3.5458596	-3.1959827	
350.00000	3.4529017	-3.2311901	
360.00000	3.3356066	-3.2626109	
370.00000	3.1963767	-3.2902586	
380.00000	3.0379597	-3.3141514	
390.00000	2.8586036	-3.3343126	
400.00000	2.6675712	-3.3550110	
410.00000	2.5990867	-3.3748913	
420.00000	2.7644484	-3.3914393	
430.00000	2.9188189	-3.4046858	
440.00000	3.0730952	-3.4146634	
450.00000	3.2148007	-3.4214090	
460.00000	3.3561940	-3.4249618	
470.00000	3.4866225	-3.5397916	
480.00000	3.6127975	-3.5869344	
490.00000	3.7326111	-3.5850275	
500.00000	3.8387387	-3.5485646	
510.00000	3.9468405	-3.4834175	
520.00000	4.0432333	-3.4270800	

530.00000	4.1256196	-3.6237382
540.00000	4.2130045	-3.8767179
550.00000	4.2869452	-4.0777340
560.00000	4.3506643	-4.2474442
570.00000	4.4250708	-4.3785282
580.00000	4.7218372	-4.4899491
590.00000	4.9787236	-4.5945634
600.00000	5.2252989	-4.6959245
610.00000	5.4592869	-4.8164653
620.00000	5.6826928	-4.9521055
630.00000	5.9193302	-5.0996525
640.00000	6.1351799	-5.2737662
650.00000	6.3670688	-5.4526036
660.00000	6.5542150	-5.6280300
670.00000	6.7358499	-5.8004254
680.00000	6.8506564	-6.1279792
690.00000	6.9155840	-6.4259195
700.00000	6.9157785	-6.6547459
710.00000	6.8361212	-6.8066880
720.00000	6.6805494	-6.8793806
730.00000	6.7113206	-6.8792772
740.00000	7.0420097	-6.8001143
750.00000	7.3435109	-6.6503145
760.00000	7.6167054	-6.7043719
770.00000	7.8847350	-6.9075464
780.00000	8.1104016	-7.0920961
790.00000	8.3164675	-7.2470399
800.00000	8.4986007	-7.4126824
810.00000	8.6319956	-7.5452382
820.00000	8.7628024	-7.6113077
830.00000	8.8496922	-7.6909280
840.00000	8.9005405	-7.7316801
850.00000	8.9416541	-7.9379763
860.00000	8.9308807	-7.9884284
870.00000	8.9139564	-8.0390378
880.00000	8.8609697	-8.0676199
890.00000	8.7759501	-8.0830835
900.00000	8.6821544	-8.0900394
910.00000	8.5376770	-8.0754725
920.00000	8.4046476	-8.0601012
930.00000	8.2147046	-8.0210104
940.00000	8.1023047	-7.9820142
950.00000	8.0158021	-7.9240157
960.00000	7.9092682	-7.8594835
970.00000	7.7910631	-7.7880784
980.00000	7.6872070	-7.7011219
990.00000	7.5651583	-7.6215640
1000.00000	7.4660490	-7.5117384

PROGRAM RAN TO COMPLETICN

APPENDIX C

LISTING OF THE GENERAL PROGRAM AND THE PROGRAM WITHOUT THE S-C 4020 SUBROUTINES

Listing of General Program

```
$RESTORE
$*      CHARACTRON OUTPUT TAPE ON B9
$ATTACH         B9
$AS             SYSLB4
$EXECUTE        IBJOB
$IBJOB          MAP,FIOCS                                      MELODIA
$IBFTC SNERD    LIST,NODECK
C         PROGRAMMER------ANTHONY MELODIA------------
C------- *       APPLIED MATHEMATICS LABORATORY-------------
C-----DAVID TAYLOR MODEL BASIN, WASHINGTON D.C.-----------*
C--------TELEPHONE NUMBER---AREA CODE 301, 995-1514--------*-- * - -
C
C
      DIMENSION Z(2000),T(2000),S(2000),S2ND(2000),XOMEGA(2000),X(2000),
     1XDOT(2000),ALPHA(25),OSCIL(1000) ,VEL(1000),RESID(1000)
      EQUIVALENCE (RESID,X(1)),(VEL,X(1001))
      NAMELIST/ZAZA1/Z/ZAZA2/T,TZERO,                    H,      X0,N,
     1XDOT0,ISZ/ZAZA3/IP1,IP2,IP3,IP4,IP5/ZAZA4/ALPHA,NALPHA
      WRITE(6,900)
      PI=3.1415927
      READ(5,ZAZA1)      delete if Z's are generated by the program
      READ(5,ZAZA2)
      READ(5,ZAZA3)
      READ(5,ZAZA4)
      IF(IP3)50,51,50       insert loop here if Z's are to be calibrated or
   50 IP1=0                 generated by the program, see listings of
      IP2=0                 sample problems 1 & 2
   51 CONTINUE
C
C---------- WRITE AND PLOT INPUT DATA-------------
      DO 100 I=2,N
  100 T(I)=T(I-1)+H
      IF(ISZ)104,105,104
  104 WRITE(6,901)
      GO TO 106
  105 WRITE(6,902)
  106 CONTINUE
      WRITE(6,903) (Z(I),T(I),I=1,N)
      ZMIN=Z(1)
      ZMAX=Z(1)
      DO 110 I=2,N
      IF(ZMAX-Z(I))108,109,109
  108 ZMAX=Z(I)
      GO TO 110
  109 IF(ZMIN-Z(I))110,110,107
  107 ZMIN=Z(I)
  110 CONTINUE
      CALL CAMRAV(35)
      ZN=N
      DX=H*ZN/10.
      DY=(ZMAX-ZMIN)/10.
      CALL GRID1V(1,T(1),T(N),ZMIN,ZMAX,DX,DY,1,1,1,1,6,6)
      CALL APLOTV(N,T,Z,1,1,1,42,IERR)
      IF(IERR)115,116,115
  115 WRITE(6,904) IERR
  116 CONTINUE
      NN=N-1
      DO 120 I=1,NN
      CALL LINEV(NXV(T(I)),NYV(Z(I)),NXV(T(I+1)),NYV(Z(I+1)))
  120 CONTINUE
```

```
      CALL PRINTV(-15,15HTIME IN SECONDS,452,6)
      IF(ISZ)121,122,121
  121 CALL APRNTV(0,-14,-23,23HFOUNDATION ACCELERATION,4,696)
      GO TO 123
  122 CALL APRNTV(0,-14,-19,19HFOUNDATION VELOCITY,4,664)
  123 CONTINUE
C
C----------COMPUTE S(N) AND S2ND(N) FOR EACH TIME,T--------
      S(1)=Z(2)-Z(1)
      S2ND(1)=Z(3)-2.*Z(2)+Z(1)
       K=N-1
      DO 200 I=2,K
      S(I)=Z(I+1)-Z(I)
  200 S2ND(I)=Z(I+1)-2.*Z(I)+Z(I-1)
      WRITE(6,917) (I,S(I),S2ND(I),I=1,N)
C
  190 READ(5,920) FREQ1,FREQ2,DELTAF
      IF(ABS(FREQ1-FREQ2)-.1E-20) 801,801,191
  191 CONTINUE
      IF(IP3)192,195,192
  192 TEMP=FREQ2-FREQ1
      IF(AMOD(TEMP,DELTAF)-DELTAF/2.)193,194,194
  193 NOFREQ=TEMP/DELTAF
      GO TO 195
  194 NOFREQ=TEMP/DELTAF+1.0001
  195 CONTINUE
C------DAMPED OR UNDAMPED,IF UNDAMPED FIND NUMBER OF RESIDUAL POINTS-------
      DO 800 IX=1,NALPHA
      NIN=1
      INI=0
      FREQ=FREQ1
      IF(ABS(ALPHA(IX))-.1E-09)201,201,202
  201 IALPHA=1
      GO TO 222
  202 IALPHA=2
  222 GO TO (203,207),IALPHA
  203 TT=TZERO-T(1)
       IF(AMOD(TT,H)-H/2.)205,204,204
  204 KH=TT/H+1.000001
      GO TO 207
  205 KH=TT/H+.000001
  207 CONTINUE
C
C----------COMPUTE CONSTANTS-------
      OMEGA=FREQ*2.*PI
      RADCAL=SQRT(1.-ALPHA(IX)**2)
      OH=OMEGA*H
      P=OMEGA*RADCAL
      FX=EXP(-ALPHA(IX)*OH)
      COSPH=COS(P*H)
      SINPH=SIN(P*H)
      A2OH=2.*ALPHA(IX)/OH
      RECOH=1./OH
       ALPHA2=ALPHA(IX)**2
      X12=1.-2.*ALPHA2
      FACT1=FX*SINPH/RADCAL
      FACT2=FX*COSPH+FACT1*ALPHA(IX)
      IF(ABS(FREQ)-.1E-20)220,220,221
  220 IFREQ=1
      GO TO 223
```

```
  221 IFREQ=2
  223 IF(ISZ)300,208,300
  208 GO TO (400,209),IFREQ
  209 CONTINUE
C
C------COMPUTEXOMEGA(N),XDOT FOR VELOCITY INPUT------------
      GO TO(224,225),NIN
  224 XOMEGA(1)=OMEGA*XO
      FACT3=RECOH*(1.-FACT2)
      FACT4=RECOH*(.5-2.*ALPHA(IX)*RECOH+EX*((.5+2.*ALPHA(IX)*RECOH)
     1*COSPH-(X12*RECOH-ALPHA(IX)/2.)*SINPH/RADCAL))
      FACT5=EX*COSPH-ALPHA(IX)*FACT1
      FACT6=RECOH*FACT1
      FACT7=(RECOH**2)*(1.-EX*(COSPH+(ALPHA(IX)+OH/2.)*SINPH/RADCAL))
      XDOT(1)=XDOTO
      DO 210 I=2,N
      XOMEGA(I)=XOMEGA(I-1)*FACT2+XDOT(I-1)*FACT1-S(I-1)*FACT3-S2ND(I-1)
     1*FACT4
  210 XDOT(I)=-XOMEGA(I-1)*FACT1+XDOT(I-1)*FACT5-S(I-1)*FACT6-S2ND(I-1)*
     1FACT7
       GO TO 756
  225 CONTINUE
      KRO=KMX+KOOK
      KRA=KMN+KICK
      DO 235 I=2,5
      VA=I-1
      TA=VA*.2*H
      COSPT=COS(P*TA)
      SINPT=SIN(P*TA)
      EXT=EXP(-ALPHA(IX)*OMEGA*TA)
      FACTR1=EXT*(COSPT+ALPHA(IX)*SINPT/RADCAL)
      FACTR2=EXT*SINPT/RADCAL
      FACTR3=(1.-FACTR1)*RECOH
      FACTR4=(TA/H-.5-A2OH+(ALPHA(IX)/2.-X12*RECOH)*FACTR2+(.5+A2OH)
     1*EXT*COSPT)*RECOH
      XMAXO    =XOMEGA(KRO)*FACTR1+XDOT(KRO)*FACTR2-S(KRO)*FACTR3
     1-S2ND(KRO)*FACTR4
      IF(XMAX-XMAXO    )229,230,230
  229 XMAX=XMAXO
  230 XMINO    =XOMEGA(KRA)*FACTR1+XDOT(KRA)*FACTR2-S(KRA)*FACTR3
     1-S2ND(KRA)*FACTR4
      IF(XMIN-XMINO    )235,235,232
  232 XMIN=XMINO
  235 CONTINUE
      NIN=1
  211 IF(IP1)500,212,500
  212 IF(IP2)550,213,550
  213 IF(IP3)600,214,600
  214 IF(IP4)650,215,650
  215 IF(IP5)700,785,700
C
C-----COMPUTE XOMEGA(N), XDOT(N), FOR ACCELRATION INPUT--------
  300 CONTINUE
      GO TO(350,305),IFREQ
  305 CONTINUE
      GO TO(308,325),NIN
  308 XOMEGA(1)=OMEGA*XO
      ECOS1=1.-EX*COSPH
      DFACT3=(1.-FACT2)/OMEGA
      DFACT4=(1.-A2OH*ECOS1-X12*FACT1*RECOH)/OMEGA
```

```
      DFACT5=(-4.*ALPHA(IX)-(2.*(1.-4.*ALPHA2)/OH-2.*ALPHA(IX))*ECOS1+
     1(X12+2.*ALPHA(IX)*(3.-4.*ALPHA2)/OH)*FACT1)*RECOH/(2.*OMEGA)
      DFACT6=(1.-ECOS1)-FACT1*ALPHA(IX)
      DFACT7=FACT1/OMEGA
      DFACT8=(1.-FACT2)*RECOH/OMEGA
      DFACT9=(2.-(1.+4.*ALPHA(IX)*RECOH)*ECOS1-(2.*X12*RECOH-ALPHA(IX))
     1*FACT1)*RECOH/(2.*OMEGA)
      XDOT(1)=XDOTO
      DO 310 I=2,N
      XOMEGA(I)=XOMEGA(I-1)*FACT2+XDOT(I-1)*FACT1-Z(I-1)*DFACT3-S(I-1)
     1*DFACT4-S2ND(I-1)*DFACT5
  310 XDOT(I)=-XOMEGA(I-1)*FACT1+XDOT(I-1)*DFACT6-Z(I-1)*DFACT7
     1       -S(I-1)*DFACT8-S2ND(I-1)*DFACT9
       GO TO 756
  325 CONTINUE
      KRO=KMX+KOOK
      KRA=KMN+KICK
      H2=H**2
      DO 335 I=2,5
      VA=I-1
      TA=VA*.2*H
      COSPT=COS(P*TA)
      SINPT=SIN(P*TA)
      EXT=EXP(-ALPHA(IX)*OMEGA*TA)
      FACTR1=EXT*(COSPT+ALPHA(IX)*SINPT/RADCAL)
      FACTR2=EXT*SINPT/RADCAL
      FACTR3=(1.-FACTR1)/OMEGA
      FACTR4=(TA/H-A2OH*(1.-EXT*COSPT)-X12*FACTR2*RECOH)/OMEGA
      FACTR5=(TA**2/H2-TA/H-(2.*(1.-4.*ALPHA2)*RECOH**2-A2OH)*
     1(1.-EXT*COSPT)+(X12*RECOH+2.*ALPHA(IX)*(3.-4.*ALPHA2)*RECOH**2)
     2*FACTR2)/(2.*OMEGA)
      XMAXO=XOMEGA(KRO)*FACTR1+XDOT(KRO)*FACTR2-Z(KRO)*FACTR3
     1-S(KRO)*FACTR4-S2ND(KRO)*FACTR5
      IF(XMAX-XMAXO    )329,330,330
  329 XMAX=XMAXO
  330 XMINO=XOMEGA(KRA)*FACTR1+XDOT(KRA)*FACTR2-Z(KRA)*FACTR3
     1-S(KRA)*FACTR4-S2ND(KRA)*FACTR5
      IF(XMIN-XMINO    )335,335,332
  332 XMIN=XMINO
  335 CONTINUE
      NIN=1
      GO TO 211
C
C------FREQ1=ZERO FOR FOUNDATION ACCELERATION---------
  350 GO TO(352,365),NIN
  352 XOMEGA(1)=XO
      XDOT(1)=XDOTO
      H2=H**2
      DO 360 I=2,N
      XOMEGA(I)=XOMEGA(I-1)+H*XDOT(I-1)-Z(I-1)*H2/2.-S(I-1)*H2/6.+
     1S2ND(I-1)*H2/24.
  360 XDOT(I)=-Z(I-1)*H-S(I-1)*H/2.+S2ND(I-1)*H/12.
      GO TO 756
  365 CONTINUE
      NIN=1
      GO TO 211
C
C-------COMPUTE X, XDOT FOR OMEGA=ZERO-----VELOCITY INPUT
  400 GO TO(402,425),NIN
  402 XOMEGA(1)=XO
```

```
      XDOT(1)=XDOTO
      DO 410 I=2,N
      XOMEGA(I)=XOMEGA(I-1)+XDOT(I-1)*H-S(I-1)*H*.5+S2ND(I-1)*H/12.
  410 XDOT(I)=XDOT(I-1)-S(I-1)
      GO TO 756
  425 CONTINUE
      NIN=1
      GO TO 211
C
C--------PLOT X VS. T AND XDOT VS. T------------
  500 GO TO(505,510),IFREQ
  505 DO 506 I=1,N
  506 X(I)=XOMEGA(I)
      GO TO 518
  510 DO 515 I=1,N
  515 X(I)=XOMEGA(I)/OMEGA
  518  XMX=X(1)
       XDMX=XDOT(1)
       XMN=X(1)
       XDMN=XDOT(1)
      DO 530 I=2,N
      IF(X(I)-XMX )521,521,520
  520  XMX=X(I)
  521 IF(X(I)-XMN )522,523,523
  522  XMN=X(I)
  523 IF(XDOT(I)-XDMX )525,525,524
  524  XDMX=XDOT(I)
  525 IF(XDOT(I)-XDMN )526,530,530
  526  XDMN=XDOT(I)
  530 CONTINUE
      DY=(XMX -XMN )/10.
      CALL GRIDIV(1,T(1),T(N),XMN, XMX, DX,DY,1,1,1,1,6,6)
      CALL APLOTV(N,T,X,1,1,1,42,IER)
      IF(IER)531,532,531
  531 WRITE(6,913) IER,FREQ
  532 NN=N-1
      DO 535 I=1,NN
      CALL LINEV(NXV(T(I)),NYV(X(I)),NXV(T(I+1)),NYV(X(I+1)))
  535 CONTINUE
      CALL PRINTV(-15,15HTIME IN SECONDS,452,6)
      CALL PRINTV(-23,23HFREQ=          CYCLES/SEC.,20,3)
      CALL LABLV(FREQ,60,3,6,1,4)
      CALL PRINTV(-8,8HALPHA=  ,20,17)
      CALL LABLV(ALPHA(IX),72,17,6,1,1)
      CALL APRNTV(0,-14,-11,11HX  RESPONSE,4,600)
      DY=(XDMX -XDMN )/10.
      CALL GRIDIV(1,T(1),T(N),XDMN, XDMX, DX,DY,1,1,1,1,6,6)
      CALL APLOTV (N,T,XDOT, 1,1,1,42,IERA)
      IF(IERA) 538,539,538
  538 WRITE(6,914) IERA,FREQ
  539 DO 540 I=1,NN
      CALL LINEV(NXV(T(I)),NYV(XDOT(I)),NXV(T(I+1)),NYV(XDOT(I+1)))
  540 CONTINUE
      CALL PRINTV(-15,15HTIME IN SECONDS,452,6)
      CALL PRINTV(-23,23HFREQ=          CYCLES/SEC.,20,3)
      CALL LABLV(FREQ,60,3,6,1,4)
      CALL PRINTV(-8,8HALPHA=  ,20,17)
      CALL LABLV(ALPHA(IX),72,17,6,1,1)
      CALL APRNTV(0,-14,-22,22HVELOCITY RESPONSE XDOT,4,688)
      GO TO 212
```

```
C
C---------PLOT Y(ACCELERATION) VS. TIME-----------
  550 CONTINUE
      GO TO(213,551),IFREQ
  551 CONTINUE
  560 DO 562 I=1,N
  562 X(I)=-XOMEGA(I)*OMEGA
       XMX=X(1)
       XMN=X(1)
      DO 566 I=2,N
      IF(XMX -X(I))563,564,564
  563  XMX=X(I)
  564 IF(XMN -X(I))566,566,565
  565  XMN=X(I)
  566 CONTINUE
      DY=(XMX -XMN )/10.
      CALL GRID1V(1,T(1),T(N),XMN, XMX, DX,DY,1,1,1,1,6,6)
      CALL APLOTV(N,T,X,1,1,1,42,IERR)
      IF(IERR)570,571,570
  570 WRITE(6,919) IERR,FREQ
  571 NN=N-1
      DO 575 I=1,NN
      CALL LINEV(NXV(T(I)),NYV(X(I)),NXV(T(I+1)),NYV(X(I+1)))
  575 CONTINUE
      CALL PRINTV(-15,15HTIME IN SECONDS,452,6)
      CALL PRINTV(-23,23HFREQ=        CYCLES/SEC.,20,3)
      CALL LABLV(FREQ,60,3,6,1,4)
      CALL PRINTV(-8,8HALPHA=  ,20,17)
      CALL LABLV(ALPHA(IX),72,17,6,1,1)
      CALL APRNTV(0,-14,-34,34HMINUS PSEUDO RESPONSE ACCELERATION,
     14,844)
      GO TO 214
C
C
C------- -      FOUR COORDINATE GRID------
  600 CONTINUE
      INI=1+INI
      OSCIL(INI)=FREQ
      VEL(INI)=AMAX1(ABS(XMAX),ABS(XMIN))
      GO TO (601,602),IALPHA
  601 RESID(INI)=SQRT(XOMEGA(KH)**2+XDOT(KH)**2)
      IF(RESID(INI)-.1E-19)604,604,602
  602 IF(FREQ-.1E-19)604,604,603
  603 IF(VEL(INI)-.1E-19)604,604,605
  604 NOFREQ=NOFREQ-1
      INI=INI-1
  605 IF(ABS(FREQ-FREQ2)-.1E-09)606,606,214
  606 CONTINUE
      CALL SMXYV(1,1)
      FRQSML=OSCIL(1)
      VELSML=VEL(1)
      RESSML=RESID(1)
      DO 616 I=2,NOFREQ
      IF(OSCIL(I)-FRQSML)611,612,612
  611 FRQSML=OSCIL(I)
  612 IF(VEL(I)-VELSML)613,614,614
  613 VELSML=VEL(I)
  614 IF(RESID(I)-RESSML)615,615,616
  615 RESSML=RESID(I)
  616 CONTINUE
```

```
      ORDSML=AMIN1(VELSML,RESSML)
C
C-------TO FIND THE LIMITS FOR THE (4X3) CYCLES-----------
C
      IF(ALOG10(ORDSML))620,621,621
  620 LOGORD=ALOG10(ORDSML)-1.
      GO TO 622
  621 LOGORD=ALOG10(ORDSML)
  622 IF(ALOG10(FRQSML))623,624,624
  623 LOGFRQ=ALOG10(FRQSML)-1.
      GO TO 625
  624 LOGFRQ=ALOG10(FRQSML)
  625 ORDSML=10.**LOGORD
      ORDLG=ORDSML*10.**4
      FRQSML=10.**LOGFRQ
      FRQLG=FRQSML*10.**3
C-----PLOT LOG-LOG GRID FOR VELOCITY VS FREQUENCY-------
      CALL GRID1V(1,FRQSML,FRQLG,ORDSML,ORDLG,1.0,1.0,1,1,1,1,-2,-2)
C-----TO FIND LARGEST 1X10 TO THE PTH POWER LINE FOR X--------
      OMSTRT=2.*PI*FRQSML
      TEMP=ALOG10(ORDLG/OMSTRT)
      IF(TEMP)627,628,628
  627 LOP=TEMP-1.
      GO TO 629
  628 LOP=TEMP
  629 D1=10.**LOP
      V1=OMSTRT*D1
      WIG=10.*ORDSML
      XMARGN=NXV(FRQLG)-NXV(FRQSML)
      YMARGN=NYV(ORDLG)-NYV(WIG)
      SLOPE=YMARGN/XMARGN
      IXCOR=4+NXV(FRQSML)
      CALL PRINTV(-1,1HD,IXCOR,NYV(V1))
      CALL PRINTV(-2,2HD=,900,17)
      CALL LABLV(D1,924,17,-2,1,3)
C------DRAW LINES UP FROM V1-----------
      VIS=0.
      DO 632 I=1,9
      VIS=VIS+V1
      IF(ORDLG-VIS)647,630,630
  630 XTCH=NYV(ORDLG)-NYV(VIS)
      ITCH=XTCH/SLOPE
      ITCH=NXV(FRQSML)+ITCH
      KITCH=NYV(ORDLG)
      CALL LINEV (NXV(FRQSML),NYV(VIS),ITCH,KITCH)
  632 CONTINUE
C-------DRAW LINES FROM V1 DOWN----------
  647 DO 638 J=1,20
      LAL=LOP-J
      LAN=LAL+1
      DLAN=10.**LAN
      DLAL=10.**LAL
      DO 638 I=1,9
      FFT1=I
      VIS=OMSTRT*DLAN-OMSTRT*DLAL*EFT1
      IF(VIS-ORDSML)639,633,633
  633 KITCH=NYV(ORDLG)-NYV(VIS)
      IYMARG=YMARGN
      IF(IYMARG-KITCH)635,634,634
  634 ZITCH=KITCH
```

```
      ITCH=ZITCH/SLOPE
      GO TO 637
  635 ITCH=XMARGN
      KITCH=YMARGN
  637 ITCH=ITCH+NXV(FRQSML)
      KITCH=KITCH+NYV(VIS)
      CALL LINEV (NXV(FRQSML),NYV(VIS),ITCH,KITCH)
  638 CONTINUE
C------DRAW FROM THE RIGHT ORDINATE THE REMAINING X-LINES------
  639 OMLAST=2.*PI*FRQLG
      LEFT2=J
      LEFT1=EFT1
      DO 641 J=LEFT2,30
      LAL=LOP-J
      LAN=LAL+1
      DLAN=10.**LAN
      DLAL=10.**LAL
      DO 640 I=LEFT1,9
      EFT1=I
      VIS=OMLAST*DLAN-OMLAST*DLAL*EFT1
      IF(VIS-ORDSML)642,636,636
  636 KITCH=NYV(VIS)-NYV(ORDSML)
      CAPT=KITCH
      ITCH=CAPT/SLOPE
      ITCH=NXV(FRQLG)-ITCH
      KITCH=NYV(ORDSML)
      CALL LINEV (NXV(FRQLG),NYV(VIS), ITCH, KITCH)
  640 CONTINUE
      LEFT1=1
  641 CONTINUE
  642 CONTINUE
C----------PLOT POINTS-------
      CALL APLOTV(NOFREQ,OSCIL,VEL,1,1,1,44,LIT)
      IF(LIT)643,644,643
  643 WRITE(6,922) LIT,ALPHA(IX)
  644 GO TO (648,646),IALPHA
  648 CALL APLOTV(NOFREQ,OSCIL,RESID,1,1,1,38,KIT)
      CALL PRINTV(-28,28HOOO =RESIDUAL SHOCK SPECTRUM,NXV(FRQSML),1006)
      IF(KIT)645,646,645
  645 WRITE(6,923) KIT,ALPHA(IX)
  646 CONTINUE
      CALL PRINTV(-15,15HFREQUENCY (CPS),452,6)
      CALL APRNTV(0,-14,-8,8HVELOCITY,9,576)
      CALL PRINTV(-8,8HALPHA=   ,20,17)
      CALL LABLV(ALPHA(IX),72,17,6,1,1)
      CALL PRINTV(-19,19H*** =SHOCK SPECTRUM,NXV(FRQSML),1015)
C---------*  GENERATION OF ACCELERATION GRID-------
C---------- TO FIND A1------------
      TEMP=ALOG10(ORDSML*OMSTRT)
      IF(TEMP)850,851,851
  850 LOP=TEMP
      GO TO 853
  851 LOP=TEMP+1.
  853 A1=10.**LOP
      V1=A1/OMSTRT
      CALL PRINTV(-1,1HA,IXCOR,NYV(V1))
      CALL PRINTV(-2,2HA=,900,4)
      CALL LABLV(A1,924,4,-2,1,3)
C------DRAW LINES DOWN FROM A1-------
      KITCH=NYV(ORDSML)
```

```
      DO 856 I=1,9
      EFT1=I-1
      VIS=V1*(1.-.1*EFT1)
      IF(ORDSML-VIS)855,855,857
  855 XTCH=NYV(VIS)-NYV(ORDSML)
      ITCH=XTCH/SLOPE
      ITCH=ITCH+NXV(FRQSML)
      CALL LINEV (NXV(FRQSML),NYV(VIS),ITCH, KITCH)
  856 CONTINUE
C--------DRAW LINES FROM A1 UP-------------
  857 DO 870 J=1,20
      LAN=LOP+J-1
      ALAN=10.**LAN
      DO 870 I=2,10
      EFT1=I
      VIS=ALAN/OMSTRT*EFT1
      IF(VIS-ORDLG)858,858,871
  858 KITCH=NYV(VIS)-NYV(ORDSML)
      IYMARG=YMARGN
      IF(IYMARG-KITCH)862,861,861
  861 ZITCH=KITCH
      ITCH=ZITCH/SLOPE
      KITCH=NYV(ORDSML)
      GO TO 868
  862 ITCH=XMARGN
      KITCH=NYV(VIS)-IYMARG
  868 ITCH=ITCH+NXV(FRQSML)
      CALL LINEV (NXV(FRQSML),NYV(VIS),ITCH, KITCH)
  870 CONTINUE
C--------DRAW FROM THE RIGHT ORDINATE ,REMAINING A-LINES---------
  871 LEFT2=J
      LEFT1=EFT1
      KITCH=NYV(ORDLG)
      DO 875 J=LEFT2,30
      LAN=LOP+J-1
      ALAN=10.**LAN
      DO 874 I=LEFT1,10
      EFT1=I
      VIS=ALAN/OMLAST*EFT1
      IF(VIS-ORDLG)872,872,876
  872 CAPT=NYV(ORDLG)-NYV(VIS)
      ITCH=CAPT/SLOPE
      ITCH=NXV(FRQLG)-ITCH
      CALL LINEV (NXV(FRQLG),NYV(VIS), ITCH,KITCH)
  874 CONTINUE
      LEFT1=2
  875 CONTINUE
  876 CONTINUE
      GO TO 214
C
C-------*--  SHORT FORM----------
  650 CONTINUE
      IF(ABS(FREQ-FREQ1)-.1E-04)651,651,652
  651 WRITE(8,912) ALPHA(IX)
  652 GO TO(658,655),IALPHA
  655 XOMAX=AMAX1(ABS(XMAX),ABS(XMIN))
      GO TO(668,669),IFREQ
  658 RMAX=SQRT(XOMEGA(KH)**2+XDOT(KH)**2)
      XOMAX=AMAX1(ABS(XMAX),ABS(XMIN),ABS(RMAX))
      GO TO(681,678),IFREQ
```

```
  668 WRITE(8,906) FREQ,XOMAX
      GO TO 215
  669 WRITE(8,905) FREQ,XOMAX
      GO TO 215
  678 WRITE(8,907) FREQ,XOMAX,RMAX
      GO TO 215
  681 WRITE(8,908) FREQ,XOMAX,RMAX
      GO TO 215
C
C---------LONG FORM---------
  700 CONTINUE
      IF(ABS(FREQ-FREQ1)-.1E-04)701,701,702
  701 WRITE(6,915) ALPHA(IX)
  702 GO TO(704,705),IALPHA
  704 RMAX=SQRT(XOMEGA(KH)**2+XDOT(KH)**2)
      GO TO(743,742),IFREQ
  705 GO TO(726,727),IFREQ
  726 WRITE(6,916) FREQ,XMAX,XMIN
      GO TO 785
  727 WRITE(6,910) FREQ,XMAX,XMIN
      GO TO 785
  742 WRITE(6,910) FREQ,XMAX,XMIN,RMAX
      GO TO 785
  743 WRITE(6,911) FREQ,XMAX,XMIN,RMAX
      GO TO 785
C
C--------PRELIMINARY CALCULATIONS FOR MIN. AND MAX. RESPONSE--------
  756 GO TO (758,757),IALPHA
  757 NX=N
      GO TO 759
  758 NX=KH
  759 XMAX=XOMEGA(1)
      KMX=1
      XMIN=XOMEGA(1)
      KMN=1
      DO 760 I=2,NX
      IF(XMAX-XOMEGA(I))761,762,762
  761 XMAX=XOMEGA(I)
      KMX=I
  762 IF(XMIN-XOMEGA(I))760,765,765
  765 XMIN=XOMEGA(I)
      KMN=I
  760 CONTINUE
      IF(KMX-1)771,770,771
  770 KMX=KMX+1
  771 IF(KMX-NX)773,772,773
  772 KMX=KMX-1
  773 IF(KMN-1)775,774,775
  774 KMN=KMN+1
  775 IF(KMN-NX)777,776,777
  776 KMN=KMN-1
  777 CONTINUE
      IF(XDOT(KMX-1)*XDOT(KMX))778,778,779
  778 KOOK=-1
      GO TO 781
  779 KOOK=0
  781 CONTINUE
      IF(XDOT(KMN-1)*XDOT(KMN))783,783,784
  786 KICK=-1
      GO TO 950
```

```
  784 KICK=0
  950 NIN=2
      GO TO 207
C
C-------EITHER RESTART WITH NEW FREQ. OR RESTART WITH NEW ALPHA OR STOP
  785 CONTINUE
      IF(ABS(FREQ-FREQ2)-.1E-03)800,755,755
  755 FREQ=FREQ+DELTAF
       GO TO 207
  800 CONTINUE
      GO TO 190
  801 WRITE(6,909)
      CALL FRAMEV
      STOP
C
  900 FORMAT(1H1,49X,22HSHOCK SPECTRUM PROGRAM//50X,21HAPPLIED MATH LAB
     1DTMB,///)
  901 FORMAT(40X,38HFOUNDATION ACCELERATION VS TIME(INPUT)//18X,23HFOUND
     1ATION ACCELERATION,36X,15HTIME IN SECONDS)
  902 FORMAT(42X,35HFOUNDATION VELOCITY VS TIME (INPUT)//20X,19HFOUNDATI
     1ON VELOCITY,35X,15HTIME IN SECONDS)
  903 FORMAT(1X,F35.9, 44X,F20.9)
  904 FORMAT(47H  PLOTTING ERROR NUMBER OF POINTS OUT OF RANGE=,I2//)
  905 FORMAT(15X,F10.5,29X,F12.7)
  906 FORMAT(10X,11HFIRST FREQ=,F10.5,7X,13HMAX RESPONSE=,F12.7/)
  907 FORMAT(15X,F10.5,2(29X,F12.7))
  908 FORMAT(10X,11HFIRST FREQ=,F10.5,7X,13HMAX RESPONSE=,F12.7,12X,
     117HMAX RES RESPONSE=,F12.7)
  909 FORMAT(///38X,25HPROGRAM RAN TO COMPLETION)
  910 FORMAT(10X,F10.5,3(18X,F12.7))
  911 FORMAT(5X,11HFIRST FREQ=,F10.5,9X,9HMAX RESP=,F12.7,10X,9HMIN RESP
     1=,F12.7,7X,15HMAX RESID RESP=,F12.7)
  912 FORMAT(1H1,55X,10HSHORT FORM//45X,20HDAMPING COEFFICIENT=,F10.8///
     1/9X,22HFREQUENCY(CYCLES/SEC.),19X,20HMAX RESPONSE X OMEGA,18X,26HM
     2AX RESID RESPONSE X OMEGA)
  916 FORMAT(59H  PLOTTING ERROR FOR X VS T, NUMBER OF POINTS OUT OF RAN
     1GE=,I2,6H FREQ=,F10.7//)
  914 FORMAT(1X,I2,43H POINTS OUT OF RANGE FOR XDOT VS TIME,FREQ=,F10.7
     1//)
  915 FORMAT(1H1,55X,9HLONG FORM//45X,20HDAMPING COEFFICIENT=,F10.8////
     17X,16HFREQ(CYCLES/SEC),12X,20HMAX RESPONSE X OMEGA,10X,20HMIN RESP
     2ONSE X OMEGA,8X,22HMAX RESID RESP X OMEGA)
  916 FORMAT(4X,11HFIRST FREQ=,F10.5,10X,9HMAX RESP=,F12.7,10X,9HMIN RES
     1P=,F12.7)
  917 FORMAT(1H1,18X,1HI,38X,4HS(I),34X,7HS2ND(I)//
     1(17X,I4,34X,F12.7,28X,F12.7))
  918 FORMAT(1H1,50X,19HINTERMEDIATE VALUES/19X,1HI,35X,9HXOMEGA(I),
     131X,7HXDOT(I)//
     2(17X,I3,34X,F12.7,28X,F12.7))
  919 FORMAT(1X,I2,43H POINTS OUT OF RANGE FOR Y    VS TIME,FREQ=,F10.7
     1//)
  920 FORMAT(3F20.8)
  921 FORMAT(6F15.6)
  922 FORMAT(1X,I2,49H POINTS OUT OF RANGE FOR VEL VS. FREQ WITH ALPHA=,
     1F10.8)
  926 FORMAT(1X,I2,50H POINTS OUT OF RANGE FOR RESIDUAL PLOT WITH ALPHA=
     1,  F10.8)
       END
```

Listing of the Alternate Program (no S-C 4020 required)

```
$EXECUTE      IBJOB
$IBJOB        MAP,FIOCS                                        MELODIA
$IBFTC SNFRD  LIST,NODECK
C       PROGRAMMER------ANTHONY MELODIA------------
C---- --           APPLIED MATHEMATICS LABORATORY----------- -
C-----DAVID TAYLOR MODEL BASIN, WASHINGTON D.C.-----------
C--------TELEPHONE NUMBER---AREA CODE 301, 995-1514-------- --
C
C
      DIMENSION Z(2500),T(2500),S(2500),S2ND(2500),XOMEGA(2500),
     1XDOT(2500),ALPHA(25)
      NAMELIST/ZAZA1/Z/ZAZA2/T,TZERO,                   H,      XO,N,
     1XDOTO,ISZ/ZAZA3/IP4,IP5/ZAZA4/ALPHA,NALPHA
      WRITE(6,900)
      PI=3.1415927
      READ(5,ZAZA1)      delete if Z's are to be generated by the program
      READ(5,ZAZA2)
      READ(5,ZAZA3)
      READ(5,ZAZA4)
C
C---------- WRITE AND PLOT INPUT DATA----------- *-
      DO 100 I=2,N             insert loop here if Z's are to be calibrated or
  100 T(I)=T(I-1)+H            generated by the program, see listings of sample
      IF(ISZ)104,105,104       problems 1 & 2
  104 WRITE(6,901)
      GO TO 106
  105 WRITE(6,902)
  106 CONTINUE
      WRITE(6,903)   (Z(I),T(I),I=1,N)
C
C----------COMPUTE S(N) AND S2ND(N) FOR EACH TIME,T--------
      S(1)=Z(2)-Z(1)
      S2ND(1)=Z(3)-2.*Z(2)+Z(1)
       K=N-1
      DO 200 I=2,K
      S(I)=Z(I+1)-Z(I)
  200 S2ND(I)=Z(I+1)-2.*Z(I)+Z(I-1)
      WRITE(6,917) (I,S(I),S2ND(I),I=1,N)
C
  190 READ(5,920) FREQ1,FREQ2,DELTAF
      IF(ABS(FREQ1-FREQ2)-.1E-20) 801,801,191
  191 CONTINUE
C------DAMPED OR UNDAMPED,IF UNDAMPED FIND NUMBER OF RESIDUAL POINTS-------
      DO 800 IX=1,NALPHA
      NIN=1
      FREQ=FREQ1
      IF(ABS(ALPHA(IX))-.1E-09)201,201,202
  201 IALPHA=1
      GO TO 222
  202 IALPHA=2
  222 GO TO (203,207),IALPHA
  203 TT=TZERO-T(1)
       IF(AMOD(TT,H)-H/2.)205,204,204
  204 KH=TT/H+1.000001
      GO TO 207
  205 KH=TT/H+.000001
  207 CONTINUE
C
C---------COMPUTE CONSTANTS-------
      OMEGA=FREQ*2.*PI
```

```
      RADCAL=SQRT(1.-ALPHA(IX)**2)
      OH=OMEGA*H
      P=OMEGA*RADCAL
      EX=EXP(-ALPHA(IX)*OH)
      COSPH=COS(P*H)
      SINPH=SIN(P*H)
      A2OH=2.*ALPHA(IX)/OH
      RECOH=1./OH
       ALPHA2=ALPHA(IX)**2
      X12=1.-2.*ALPHA2
      FACT1=EX*SINPH/RADCAL
      FACT2=EX*COSPH+FACT1*ALPHA(IX)
      IF(ABS(FREQ)-.1E-20)220,220,221
  220 IFREQ=1
      GO TO 223
  221 IFREQ=2
  223 IF(ISZ)300,208,300
  208 GO TO (400,209),IFREQ
  209 CONTINUE
C
C------COMPUTEXOMEGA(N),XDOT FOR VELOCITY INPUT-----------
      GO TO(224,225),NIN
  224 XOMEGA(1)=OMEGA*XO
      FACT3=RECOH*(1.-FACT2)
      FACT4=RECOH*(.5-2.*ALPHA(IX)*RECOH+EX*((.5+2.*ALPHA(IX)*RECOH)
     1*COSPH-(X12*RECOH-ALPHA(IX)/2.)*SINPH/RADCAL))
      FACT5=EX*COSPH-ALPHA(IX)*FACT1
      FACT6=RECOH*FACT1
      FACT7=(RECOH**2)*(1.-EX*(COSPH+(ALPHA(IX)+OH/2.)*SINPH/RADCAL))
      XDOT(1)=XDOTO
      DO 210 I=2,N
      XOMEGA(I)=XOMEGA(I-1)*FACT2+XDOT(I-1)*FACT1-S(I-1)*FACT3-S2ND(I-1)
     1*FACT4
  210 XDOT(I)=-XOMEGA(I-1)*FACT1+XDOT(I-1)*FACT5-S(I-1)*FACT6-S2ND(I-1)*
     1FACT7
       GO TO 756
  225 CONTINUE
      KRO=KMX+KOOK
      KRA=KMN+KICK
      DO 235 I=2,5
      VA=I-1
      TA=VA*.2*H
      COSPT=COS(P*TA)
      SINPT=SIN(P*TA)
      EXT=EXP(-ALPHA(IX)*OMEGA*TA)
      FACTR1=EXT*(COSPT+ALPHA(IX)*SINPT/RADCAL)
      FACTR2=EXT*SINPT/RADCAL
      FACTR3=(1.-FACTR1)*RECOH
      FACTR4=(TA/H-.5-A2OH+(ALPHA(IX)/2.-X12*RECOH)*FACTR2+(.5+A2OH)
     1*EXT*COSPT)*RECOH
      XMAXO    =XOMEGA(KRO)*FACTR1+XDOT(KRO)*FACTR2-S(KRO)*FACTR3
     1-S2ND(KRO)*FACTR4
      IF(XMAX-XMAXO    )229,230,230
  229 XMAX=XMAXO
  230 XMINO    =XOMEGA(KRA)*FACTR1+XDOT(KRA)*FACTR2-S(KRA)*FACTR3
     1-S2ND(KRA)*FACTR4
      IF(XMIN-XMINO    )235,235,232
  232 XMIN=XMINO
  235 CONTINUE
      NIN=1
```

```
  214 IF(IP4)650,215,650
  215 IF(IP5)700,785,700
C
C-----COMPUTE XOMEGA(N), XDOT(N), FOR ACCELRATION INPUT--------
  300 CONTINUE
      GO TO(350,305),IFREQ
  305 CONTINUE
      GO TO(308,325),NIN
  308 XOMEGA(1)=OMEGA*XO
      ECOS1=1.-EX*COSPH
      DFACT3=(1.-FACT2)/OMEGA
      DFACT4=(1.-A2OH*ECOS1-X12*FACT1*RECOH)/OMEGA
      DFACT5=(-4.*ALPHA(IX)-(2.*(1.-4.*ALPHA2)/OH-2.*ALPHA(IX))*ECOS1+
     1(X12+2.*ALPHA(IX)*(3.-4.*ALPHA2)/OH)*FACT1)*RECOH/(2.*OMEGA)
      DFACT6=(1.-ECOS1)-FACT1*ALPHA(IX)
      DFACT7=FACT1/OMEGA
      DFACT8=(1.-FACT2)*RECOH/OMEGA
      DFACT9=(2.-(1.+4.*ALPHA(IX)*RECOH)*ECOS1-(2.*X12*RECOH-ALPHA(IX))
     1*FACT1)*RECOH/(2.*OMEGA)
      XDOT(1)=XDOTO
      DO 310 I=2,N
      XOMEGA(I)=XOMEGA(I-1)*FACT2+XDOT(I-1)*FACT1-Z(I-1)*DFACT3-S(I-1)
     1*DFACT4-S2ND(I-1)*DFACT5
  310 XDOT(I)=-XOMEGA(I-1)*FACT1+XDOT(I-1)*DFACT6-Z(I-1)*DFACT7
     1       -S(I-1)*DFACT8-S2ND(I-1)*DFACT9
       GO TO 756
  325 CONTINUF
      KRO=KMX+KOOK
      KRA=KMN+KICK
      H2=H**2
      DO 335 I=2,5
      VA=I-1
      TA=VA*.2*H
      COSPT=COS(P*TA)
      SINPT=SIN(P*TA)
      EXT=EXP(-ALPHA(IX)*OMEGA*TA)
      FACTR1=EXT*(COSPT+ALPHA(IX)*SINPT/RADCAL)
      FACTR2=EXT*SINPT/RADCAL
      FACTR3=(1.-FACTR1)/OMEGA
      FACTR4=(TA/H-A2OH*(1.-EXT*COSPT)-X12*FACTR2*RECOH)/OMEGA
      FACTR5=(TA**2/H2-TA/H-(2.*(1.-4.*ALPHA2)*RECOH**2-A2OH)*
     1(1.-EXT*COSPT)+(X12*RECOH+2.*ALPHA(IX)*(3.-4.*ALPHA2)*RECOH**2)
     2*FACTR2)/(2.*OMEGA)
      XMAXO=XOMEGA(KRO)*FACTR1+XDOT(KRO)*FACTR2-Z(KRO)*FACTR3
     1-S(KRO)*FACTR4-S2ND(KRO)*FACTR5
      IF(XMAX-XMAXO    )329,330,330
  329 XMAX=XMAXO
  330 XMINO=XOMEGA(KRA)*FACTR1+XDOT(KRA)*FACTR2-Z(KRA)*FACTR3
     1-S(KRA)*FACTR4-S2ND(KRA)*FACTR5
      IF(XMIN-XMINO    )335,335,332
  332 XMIN=XMINO
  335 CONTINUE
      NIN=1
      GO TO 214
C
C------FREQ1=ZERO FOR FOUNDATION ACCELERATION---------
  350 GO TO(352,365),NIN
  352 XOMEGA(1)=XO
      XDOT(1)=XDOTO
      H2=H**2
```

```
      DO 360 I=2,N
      XOMEGA(I)=XOMEGA(I-1)+H*XDOT(I-1)-Z(I-1)*H2/2.-S(I-1)*H2/6.+
     1S2ND(I-1)*H2/24.
  360 XDOT(I)=-Z(I-1)*H-S(I-1)*H/2.+S2ND(I-1)*H/12.
      GO TO 756
  365 CONTINUE
      NIN=1
      GO TO 214
C
C-------COMPUTE X, XDOT FOR OMEGA=ZERO-----VELOCITY INPUT
  400 GO TO(402,425),NIN
  402 XOMEGA(1)=X0
      XDOT(1)=XDOT0
      DO 410 I=2,N
      XOMEGA(I)=XOMEGA(I-1)+XDOT(I-1)*H-S(I-1)*H*.5+S2ND(I-1)*H/12.
  410 XDOT(I)=XDOT(I-1)-S(I-1)
      GO TO 756
  425 CONTINUE
      NIN=1
      GO TO 214
C
C------- --  SHORT FORM----------
  650 CONTINUE
      IF(ABS(FREQ-FREQ1)-.1E-04)651,651,652
  651 WRITE(8,912) ALPHA(IX)
  652 GO TO(658,655),IALPHA
  655 XOMAX=AMAX1(ABS(XMAX),ABS(XMIN))
      GO TO(668,669),IFREQ
  658 RMAX=SQRT(XOMEGA(KH)**2+XDOT(KH)**2)
      XOMAX=AMAX1(ABS(XMAX),ABS(XMIN),ABS(RMAX))
      GO TO(681,678),IFREQ
  668 WRITE(8,906) FREQ,XOMAX
      GO TO 215
  669 WRITE(8,905) FREQ,XOMAX
      GO TO 215
  678 WRITE(8,907) FREQ,XOMAX,RMAX
      GO TO 215
  681 WRITE(8,908) FREQ,XOMAX,RMAX
      GO TO 215
C
C---------LONG FORM---------
  700 CONTINUE
      IF(ABS(FREQ-FREQ1)-.1E-04)701,701,702
  701 WRITE(6,915) ALPHA(IX)
  702 GO TO(704,705),IALPHA
  704 RMAX=SQRT(XOMEGA(KH)**2+XDOT(KH)**2)
      GO TO(743,742),IFREQ
  705 GO TO(726,727),IFREQ
  726 WRITE(6,916) FREQ,XMAX,XMIN
      GO TO 785
  727 WRITE(6,910) FREQ,XMAX,XMIN
      GO TO 785
  742 WRITE(6,910) FREQ,XMAX,XMIN,RMAX
      GO TO 785
  743 WRITE(6,911) FREQ,XMAX,XMIN,RMAX
      GO TO 785
C
C--------PRELIMINARY CALCULATIONS FOR MIN. AND MAX. RESPONSE---------
  756 GO TO (758,757),IALPHA
  757 NX=N
```

```
      GO TO 759
  758 NX=KH
  759 XMAX=XOMEGA(1)
      KMX=1
      XMIN=XOMEGA(1)
      KMN=1
      DO 760 I=2,NX
      IF(XMAX-XOMEGA(I))761,762,762
  761 XMAX=XOMEGA(I)
      KMX=I
  762 IF(XMIN-XOMEGA(I))760,765,765
  765 XMIN=XOMEGA(I)
      KMN=I
  760 CONTINUE
      IF(KMX-1)771,770,771
  770 KMX=KMX+1
  771 IF(KMX-NX)773,772,773
  772 KMX=KMX-1
  773 IF(KMN-1)775,774,775
  774 KMN=KMN+1
  775 IF(KMN-NX)777,776,777
  776 KMN=KMN-1
  777 CONTINUE
      IF(XDOT(KMX-1)*XDOT(KMX))778,778,779
  778 KOOK=-1
      GO TO 781
  779 KOOK=0
  781 CONTINUE
      IF(XDOT(KMN-1)*XDOT(KMN))783,783,784
  783 KICK=-1
      GO TO 950
  784 KICK=0
  950 NIN=2
      GO TO 207
C
C-------EITHER RESTART WITH NEW FREQ. OR RESTART WITH NEW ALPHA OR STOP
  785 CONTINUE
      IF(ABS(FREQ-FREQ2)-.1E-03)800,755,755
  755 FREQ=FREQ+DELTAF
       GO TO 207
  800 CONTINUE
      GO TO 190
  801 WRITE(6,909)
      STOP
C
  900 FORMAT(1H1,49X,22HSHOCK SPECTRUM PROGRAM//50X,21HAPPLIED MATH LAB
     1DTMB,///)
  901 FORMAT(40X,38HFOUNDATION ACCELERATION VS TIME(INPUT)//18X,23HFOUND
     1ATION ACCELERATION,36X,15HTIME IN SECONDS)
  902 FORMAT(42X,35HFOUNDATION VELOCITY VS TIME (INPUT)//20X,19HFOUNDATI
     1ON VELOCITY,35X,15HTIME IN SECONDS)
  903 FORMAT(1X,F35.9, 44X,F20.9)
  905 FORMAT(15X,F10.5,29X,F12.7)
  906 FORMAT(10X,11HFIRST FREQ=,F10.5,7X,13HMAX RESPONSE=,F12.7/)
  907 FORMAT(15X,F10.5,2(29X,F12.7))
  908 FORMAT(10X,11HFIRST FREQ=,F10.5,7X,13HMAX RESPONSE=,F12.7,12X,
     117HMAX RES RESPONSE=,F12.7)
  909 FORMAT(///38X,25HPROGRAM RAN TO COMPLETION)
  910 FORMAT(10X,F10.5,3(18X,F12.7))
  911 FORMAT(5X,11HFIRST FREQ=,F10.5,9X,9HMAX RESP=,F12.7,10X,9HMIN RESP
```

```
912 FORMAT(1H1,55X,10HSHORT FORM//45X,20HDAMPING COEF [illegible]
   1/9X,22HFREQUENCY(CYCLES/SEC.),19X,20HMAX RESPONSE X OMEGA,18X,26HM
   2AX RESID RESPONSE X OMEGA)
915 FORMAT(1H1,55X,9HLONG FORM//45X,20HDAMPING COEFFICIENT=,F10.8////
   17X,16HFREQ(CYCLES/SEC),12X,20HMAX RESPONSE X OMEGA,10X,20HMIN RESP
   2ONSE X OMEGA,8X,22HMAX RESID RESP X OMEGA)
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920 FORMAT(3F20.8)
921 FORMAT(6F15.6)
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Research Laboratory Report 5772 (Jun 1962).

2. Gertel, M. and Holland, R., "Definition of Shock Design and Test Criteria Using Shock and Fourier Spectra of Transient Environments," Document No. DYN-65-1, Allied Research Associates, Inc., Virginia Road, Concord, Mass. (Oct 1965).

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2. Shock--Spectra--Computer programming
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4. Shock--Structural response --Mathematical analysis
5. FORTRAN IV (Computer program language)

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